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PERSPECTIVE PLAN OF WATERSHED MANAGEMENT OF HIMALAYAN REGION

ANIL BERRY

Watershed Management Project, Pauri (U.P.)

Introduction

The Himalayan region extends from West to East along the northern boundary of India for nearly 2500 kms. It has a width varying from 250 to 300 kms. Geographically it may be divided in to 3 sub-regions viz. The Western Himalayas, Central Himalayas and the North-Eastern Himalayas. The region has a complex eco-system and extends over an area of 594427 km^2. covering 12 States.

Most of our major rivers of Northern India originate from this region. The fragile Himalayan eco-system has been badly disturbed due to the past mis-management, manifold increase in human and cattle population, over fellings and extensive road building work in this region. It has destroyed the productive potential of the Himalayas and has become the major cause of floods in plains down stream. The standard of living of rural hill people is deteriorating instead of improving. The hill women now have to go to a distance of an average of 6.5 kms to fetch fuelwood, grass and leaf-litter and 0.75 km to fetch drinking water, as per a study in Machlad area of Pauri district (U.P.) (Anon. 1986) showed. Her routine household works take nearly 16 hours/day.

The massive floods in Gangetic plains are increasing in their damaging intensity. tabulated below is an average for the period 1953 to 1981.

To improve the lot of local people and to check and reverse the eco-degradation of the Himalayas (inturn reducing the flood damages to the plains) the urgent treatment of Himalayan region becomes imperative. The Watershed Management concept is one major thrust in this direction. Under it an organised, planned and inter-disciplinary area development works are being carried out. Projects i.e. Dhauladhar region of H.P. (West German aided), E.E.C. aided in Chamba region of U.P., and in West Bengal, World Bank aided Nayar-Panar Catchment Project in U.P. are now being run basically on this concept. This concept of Watershed Management should be extended over whole

Component	Unit	Total 1953–81	Maximum in one year	Average/year
Total area affected	Million ha	235.6	19 (1978)	8.1
Population involved	Million	795.0	70 (1978)	27.4
Damage to crops	Millon ha	104.0	10 (1978)	3.6
	US. $M	7200.0	1030 (1978)	248 3
	Crore Rs.*	9360.0	1339 (1978)	322.8
Cattle lost	Thousand	2826.0	618 (1979)	97.4
Human life lost	Thousand	40.0	11 (1977)	1.4
Damage to public utilities	U.S. $M	3200.0	582 (1981)	110.3
	Crore Rs.	4160.0	757 (1981)	143.4
Total damage to crops house and public utilities**	U.S. $M.	11800.0	1700 (1978)	406.9
	Crore Rs.	15340.0	2210 (1978)	529.0

Source : W.B. (1983) (Anon. 1986)

Note : *1 U.S. $ = Rs. 13/-

**It does not include indirect damages.

of Himalayas in a phased manner taking priority (highly eroding) areas first to eventually cover the whole region.

This paper makes an attempt to develop a perspective plan for it. With the present level of knowledge one must envisage initially the total quantum of problem. Then one may proceed to solve it in a well defined phased manner or as and when the funds are available. But initial delineation of problem and the basic planning effort or data base needed for it is the pre-requisite for formulation of a realistic mid-term (five year) or a project plan at any time.

The Region

The Himalayan region can be divided into 3 units covering 12 States. The area of each State falling in Himalayan region is given in Table 1. For practical purposes the total area in Himalayan region is 473578 km^2.

The landuse pattern in each State is also given in Tabl: 1. As per this, the area under fo.est is 53.2% and under agriculture only 9.7%. The comparative data for U.P. (1983-84) is given in Table 2. As per it the forest area is 64.43% and net sown area in 13.46%.

Data base and Plan formulation

For realistic plan or project formulation, collection of basic data would be a pre-requisite. The region (State of its zone) be split into 'Catchments' of major rivers and then each catchment be split into 'Watersheds', (WS) of major tributaries. Each watershed may then progressively be split into 'Sub-Watershed' (SWS) and 'Mini-

Table 1

Land use pattern—in Himalayan region

Area-1000 ha.

State/Union Territories/ Sub-regions	Geographical area	Reporting area	Percentage distribution of reporting area				
			Forest	Area not available for cultivation.	Other than cultivated area excluding fallow	Fallow including current fallows	Net area sown
Western Himalayas							
Jammu & Kashmir	22224*	4523	61.4	11.7	9.1	2.2	15.6
Himachal Pradesh	5567	5076	54.8	5.7	27.5	1.2	10.8
Central Himalayas							
U.P. hill districts	5144	4880	46.7	30.6	4.6	1.0	17.1
N.E. Himalayas							
Manipur	2236	2211	27.2	65 4	1.1	Nil	6.3
Arunachal Pradesh	8358	5644	91 31	0.7	3.0	3.0	2.0
Darjeeling (district of West Bengal)	308	311	38.1	23.5	5.1	1.2	32.1
Sikkim	729	NA	36.0	NA	NA	NA	NA
Assam	7853	1522	22.1	74.4	Nil	Nil	3.5
Meghalaya	2248	2249	8.3	84.5	Nil	Nil	7.2
Nagaland	1655	1351	19.7	75.9	Nil	Nil	4.4
Mizoram	2109	2092	62.0	36.1	Nil	Nil	1.9
Tripura	1068	1048	60.1	4.9	11.6	0.5	22.8
Total	59499	30907	53 2	28.2	7.6	1.3	9.7

Source : Planning Commission (1982).

* It includes area under illegal occupations of Pakistan and China.

Table 2

Table showing the landuse in U.P. hill region

Item	Landuse pattern (Area in lakh ha 1983-84)	
	Area	(%)
Total reporting area	55.36	100.00
Forest	54.38	64 43
Barren & unculturable land	2.89	5.47
Land put to non-agricultural uses	2.20	2.25
Culturable waste	3.16	5.92
Parmanent pastures, other grazing land	2.17	4.07
Land under Miscellaneous tree crops and groves not included in net area sown.	1.85	3.47
Current Fallow	0.20	0.37
Other Fallow Land	0.33	0.62
Net area sown	7.18	13.46
Area sown more then once	4.33	8.11
Total cropped area	11.51	21.57
Gross irrigated area	3.32	6.22
Cropping intensity	—	160.31
Irrigation intensity	—	156.60

Source : VII FYP of U.P. hill region (1986)

Watersheds' (MWS). A mini-watershed may be of about 1000 to 2000 ha only and may have 4th to 5th order streams in it. This work can be done either on Survey of India (SOI) toposheets or on Satelite imageries of 1 : 250,000 scale.

The basic data collection unit be a MWS. With the help of latest possible B & W 1 : 50,000 or any near about scale aerial photographs the landuse of each MWS be marked. Three basic landuses of Forest, Agriculture and Blanks can be marked easily by a short term trained technical personel.

Altitude map be made for each MWS with the help of 1 : 50,000 scale SOI toposheets. Altitude classes of 300 m intervals be used i.e. 0 to 300 m altitude, 300 to 600 m altitude etc. upto 3000 m and then one class of 1000 m interval be used i.e. 3000 to 4000 m and then one class of above 4000 m altitude, be made.

Slope map can also be made from 1 : 50,000 SOI toposheets for each MWS using 10% slope classes upto 50% slope, then 25% classes be used upto 200% and then one class beyond 200% slope.

Details of streams be recorded from 1 : 50,000 SOI toposheets recording length of each order of stream in a MWS and their number. It will be able to give drainage density (stream length/ha) and drainage texture (number of streams/ha).

Each landuse class can be further classified into 4 erosion classes of E1 (slight), E2 (moderate), E3 (severe) and E4 (destroyed). Initial pre-classification can be done in the office on the basis of slope for agriculture and blanks and using an additional factor of tree density under forest. One system of erosion classification which may be modified and standardised before adoption for the whole country is given in Table 3.

With these pre-classifications the field parties should go to the field for ground checking. They may change erosion classes or other field information on the basis of actual field observations.

Basically all data be collected on MWS basis. For planning purposes a SWS be a unit as a MWS is too small for a project of mid-term level. For preparation of annual plan or case studies a MWS or a stills maller unit viz. 'Micro-Watershed' of about 200-300 ha may be used.

Other useful data as census, animal census, cropping intensity, cropping pattern etc. may be taken from the secondary sources of the State/district etc.

It must be mentioned here that a GOI (All India Soil and Landuse Survey) organisation is already collecting information on a classification system developed by them. That system may also be adopted but it is imperative that a National standardised system be used. The data collected by the States should be complementary to GOI data and not a duplication due to different classification system.

The above proposed pattern of data collection is being (nearly) followed by Land Survey Directorate of U.P. Forest Department and it is actually being used in developing a number of field reports (table 4) and has been found to be of practical field use and is therefore recommended. It may be adopted with some modifications, if needed, but in a standardised format.

The project reports be made of say 5 year period with one year extra as pre-execution phase and one more year at the end to absorb any spill overs.

For estimation of planning cost, the factual data of Land Survey Directorate of U.P. is being taken as a case study.

The Directorate has spent in all Rs. 78.8 lakhs upto 1986-87 since its creation in 1978-79 and has surveyed 35487 km^2 area of U.P. hills in this period. Besides field survey it has also developed a number of project reports.

As per details given above the data collection and basic project formulation cost works out to Rs. 2.20 per ha only. At 1986 price level and with some improvements in its working pattern, the cost of data collection and project formulation be within Rs. 2.5/ha or Rs. 250/km^2.

Table 3

Land alloted to erosion intensity classes

Slight (E1)	Moderate (E2)	Severe (E3)	Destroyed (E4)
(1) *Arable land/Agriculture areas* :			
(i) Natural slope upto 25%, field slope below 5%, arrangement for the disposal of excess water provided, terraced.	(i) Natural slope upto 25%, defective terracing, either field slope exceeds 5% or water disposal arrangement absent.	(i) All unterraced fields with well defined gullies.	(i) All unterraced fields with gullies, out up and heavy silt discharge.
	(ii) Slope between 25% to 60% with proper terracing.	(ii) Natural slope between 25% to 60%, defective terracing.	(ii) All defectively terraced fields beyond 60% slope.
		(iii) All slope above 60% with proper terracing.	
(2) *Grass land* :			
(i) Natural slope upto 60%, no rills.	(i) Natural slope exceeding 60%.	(i) Gullies deeper than 0.3 m and length upto 60m per ha or gullies upto 0.6 m deep and length more than 60 m per ha.	(i) Badly gullied or ravined, soil exposed heavy silt discharge.
	(ii) Gullies less than 0.3 m in depth and up to 60 m in length per ha.		
(3) *Wood land* :			
(i) Natural slope upto 60% and density of top canopy of tree species exceeding 0.7, No gullies or rills.	(i) All slope density of vegetation between 0.5 to 0.7.	(i) All slope with density of vegetation less than 0.5.	(i) Badly gullied or ravined, soil exposed, heavy silt discharge.
	(ii) Natural slope exceeding 60%, vegetation density exceeding 0.7.	(ii) Gullies deeper than 0.2 m and length upto 60 m per ha.	
	(iii) Gullies less than 0.2 m deep and covering less than 60 m per ha.		

Source Land Survey Directorate.

Therefore, as a preliminary estimate the data collection and planning cost for each State will be as under :

State	Data base and Project formulation cost (Crore Rs.)
1. *Western Himalayas*	
J & K.	2.53*
H P.	1.39
2. *Central Himalayas*	
U.P. (hill area only)	1.28
3. *North-Eastern Himalayas*	
Sikkim	0.18
W.B. (Darjeeling)	0.08
Assam	1.96
Arunachal Pradesh	2.09
Nagaland	0.41
Manipur	0.56
Mizoram	0.53
Meghalaya	0.56
Tripura	0.26
Total	Rs. 11.83 crores or say Rs 12 crore

Note : *For calculation purposes the area of J & K is taken to be 101387 km², excluding 78114 km² under illegal occupation of Pakistan, 5180 km² handed over to China by Pakistan and 37555 km² under illegal occupation of China (Anon. 1985). (2.) Total geographical area of the States are being presumed to be under non-permanent snow. This may not be true for three States of NW Himalayas.

Watershed plan execution estimates

The actual expenditure of investment which a State will need, will depend on the project/plan made on the basis of survey or the data base generated and plans prepared on that. As a preliminary estimate for perspective planning purposes the plans already proposed or under execution may give a fair indication of the investments required. The data from U.P. hills is available and so is being used for the following projections.

Table 4

Reports made by the Land Survey Directorate of U.P. Forest Department

Project	Area km²	Total estimated project cost (Lakh Rs.)
South Bhagirathi II	289.73	361
Aglar	470.26	1050
Benalgad I	427.28	741.6
Benalgad II	-do-	893.7
Amlawa Seligad	286	961
Bhimtal	215.82	360.4
Kuchgad	471.33	629.5
Godigad (Sargu)	426.71	608
Total	2587.13	5578.2

Source : Land Survey reports (1983–84 and 1985)

The World Bank Project : The World Bank appraisal report (Anon 1983) has made a tentative plan for Nayar-Panar area (3120 km.²) covering 9 SWS, 8 in Garhwal hills and 1 in Kumaun hills.

The project covers the disciplines of Forestry, Agriculture, Horticulture, Animal Husbandry, Soil Conservation, Minor Irrigation and Energy conservation. It envisages a level of investment where nearly every household gets some direct benefit of the project activity and there is enough demons-

tration of efficacy of various works which may induce every individual to take up necessary follow up work. Only this level of 'practical saturation' is aimed at. It is believed that this level of investment be only planned to start an effective chain reaction of 'total development'.

The World Bank estimated a total investment of Rs. 5513.43 lakhs, (excluding the price escalation due to inflation). It works out to an investment of Rs 1767.1/ha. Their staff costs as envisaged are lower than factual costs by about 20%. If it is added then the total cost works out to Rs. 2120.50 per ha.

Infact, the WB made plan of one SWS (168 km²) on the basis of preliminary data and then projected the total investment required over the whole project area (3120 km²).

The detailed plans of other 8 SWS have now been made (approved by U.P. Govt. and mostly by G.O.I. also) on the basis of detailed surveys. The details of these 8 SWS are as under :

SWS	Area (km²)	Project cost (exulding price escalation) (Lakhs Rs.)	Year of Project formulation
Srinagar	365.26	535.55	1984
Randigad	146.2	335.58	1985
Rudraprayag	143.71	272.66	1985
Nayar Right	103.51	267.97	1985
Panar	470.33	676.22	1985
Paschimi Nayar	744.06	988.61	1986
Nayar Left	237.64	445.25	1987
Purvi Nayar	697.21	991.49	1987
Total	2907.92	4511.33	—

It works out to an investment level of Rs. 1551.40 per ha. These projects envisage the investment which can be made in the project period of 5 years only and do not envisage at 'saturatin' the area. They, on an average, aim at solving about 70% of problem More. intensive work could not be prescribed specially in Forestry as closure of all plantable area in one go is neither legal nor practical. In other disciplines a near 'saturation' is prescribed. Therefore, 'saturation' level of investment will be about Rs. 2216.8/ha.

Within WB project a few selected mini-watersheds of 200 to 300 ha comprising a 'gram-sabha' were taken up for total treatment and their development as demonstration units. A separate mini-watershed plan for each is made in consulation with local people. The details are given in Table 5.

As per it, the average investment level is Rs. 1910.2 per ha. These plans do not include any staff cost and other infrastructural support cost. On an average, the total staff and administrative cost works out to about 25% of works cost. Therefore, the total level of investment would be Rs. 2387.75 per ha.

E.E.C. Project : An E.E.C. aided project is running since 1983 in Chamba area (Tehri district). It covers an area of 192.35 km² and would cost in all about Rs. 351.5 lakhs (excluding price escalation) i.e. an investment level of Rs. 1872.4 per ha.

Land Survey reports : A number of project reports have been prepared by the Land Survey Directorate of U.P. Forest Department, their abstract is given in Table 4.

Table 5

Table showing details of mini-watershed plans made within the World Bank Project

S.W.S.	Mini-Watershed	Area (ha)	Total investment (Rs.)
Randigad	Ujyari	318.12	6,52,209
,,	Oda	113.3	2,58,720
Srinagar	Bainjwari Malli	311.0	6,85,030
,,	Srikot-Dob	286.4	5,20,500
Rudraprayag	Baula	466.54	11,24,660
,,	Nagrasu	378.0	8,70,000
Nayar Right	Sainar-Baluni	314.0	3,92,160
,,	Daisan-Marora	268.24	2,47,920
Machlad	Ghandiyal	324.15	6,02,000
Panar	Danya-Falyant	327.34	4,80,000
Paschimi Nayar	Kandara	120.0	3,31,000
Total	—	3227.02	61,64,199

Source : Mini-watershed Plans of W.B. Project.

They envisage an investment level of Rs. 2156.13/ha.

A project report for catchment treatment has been made by the Tehri Dam organisation for the Ganga catchment upto Rishikesh. The treatable catchment area is 14,764 km², excluding 6,609 km² of snow zone (total catchment area is 21,373 km²). The project cost is Rs. 305 crores It works out to an investment of Rs. 2066 per ha of treatable land.

Recently Central Soil Conservation Research Institute, Dehra Dun has made a plan of a mini-watershed (Khandiyun ka Sain) in Pauri district. It covers an area of 307 ha and envisages on investment of Rs. 18 lakhs i.e. Rs. 5863.2 per ha.

They envisage total 'theoretical' saturation and have also planned massive engineering structures. Replicability of this plan for crores of ha of area do not appear to be practical and is therefore not being taken as investment indicator for the whole Himalayas. For certain specific areas this may be a good indicative figure.

From the above discussions the abstracted data for various investment plans are as under :

Plan/Project	Investment level (Rs./ha.)
W.B. appraisal report	2120/50
W.B. project reports	2216/80
Mini W.S. reports	2387/75
EEC report	1827/40
L.S. reports	2125/13
Ganga report	2066/-
Average	2129/10

Taking above data in account, one may summarise that on an average investment of Rs 2200 per ha i.e. Rs 2.2 lakh/km^2 (1986 price level) should suffice. The State wise investment therefore becomes as under :

State		Total estimated investment in watershed management (1986 price level) (in crore Rs.)
J & K		2230.51
H.P.		1224.81
U.P. (hill area)		1224.46
Sikkim		160.58
W.B. (Darjeeling)		67.65
Assam		1727.51
Arunachal Pradesh		518.61
Nagaland		363.59
Manipur		491.83
Mizoram		463.91
Meghalaya		494.76
Tripura		230.49
Total	Rs.	9098.71

The above level of investment should extend to (say) about 25 years period in a phased manner on a priority basis. The investment will follow the data base generation and plan formation and development of local work force of staff etc.

Keeping it in mind, an investment of about Rs. 1900 crores for a Five Year Plan starting from VIII FYP be started to effectively cover whole of Himalayan region under watershed management programme.

Conclusions

Watershed Management is the right approach for the hill development. It has already been started in some States. It should be extended over whole of Himalayas.

The actual work should follow a project execution approach. Specific projects be formulated keeping in mind the priority areas.

To determine priority area and to formulate a right and practical plan, proper data base is needed. For it a "Project Formulation and Survey Wing" be established in each state or in each region, immediately in VII plan itself. The total investment needed for it would be of the order of Rs 12 crores only.

The Survey work be done on an all India standardised format so that the data is directly Nationally addable, and understandable to all working in Himalayan region. If possible, other user agencies be also included in the standardisation committees so that the survey data is of use for total hill planning.

The Watershed Management work must be started in VIII FYP in some priority regions of each State. For it an allocation of Rs. 1900 crores be made to cover about 20% of area of each State (12 in all) in the Himalayan region.

SUMMARY

Watershed Management as an integrated multidisciplinary task covering works of Forestry, Agriculture, Horticulture, Animal Husbandry, Minor Irrigation, Soil Conservation and Energy Conservation, is the right approach for conserving Himalayan eco-system and

checking its bio-degradation. For it, proper data base be generated by collecting field information in an all India standardised format for the whole of the Himalayan region. The data collection and project formulation works are estimated to cost Rs. 12 crores. The estimated cost for executing the watershed management works in the whole hill region of India covering 12 States would be of the order or Rs. 1900 crore for a five year plan period, extending over five FYPs, @ 2200 Rs./ha based on a few case studies. These works will not only conserve Himalayas but will bring multi-farious benefits to local and down-strean communities.

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अनिल बेरी

सारांश

हिमालय प्रदेश की परिस्थिति - महति को मरक्षित करने तथा इसके जैव-ह्रास की रोकथाम के लिए सहि दृष्टि जल-विभाजन प्रबन्ध के बहु वज्ञानीय एकीकृत दृष्टिकोण अपनाना है जिसमें वानिकी, कृषि, बागवानी पशुपालन, छोटी-सिंचाई, मृदा संरक्षण और ऊर्जा के अन्तर्गत किये जाने वाले कार्य आ जाते हैं। ऐसा करने के लिए पहले समूचे हिमालय क्षेत्र के लिए एक अखिल भारतीय प्ररूप बनाकर उसमें क्षेत्र जानकारी इकट्ठा करके एक आंकड़ों का आधार बनाना होगा। आंकड़ों के संग्रह और परियोजना के कार्यों को निर्धारित करने में अनुमान है, लगभग 12 करोड़ रुपये खर्च आएगा। भारत के पूरे पहाड़ी क्षेत्र मे जिसमें बारह राज्य आते हैं, जल-विभाजन प्रबन्ध कार्यों को कराने में पांच वर्ष की योजना अवधि में, और यह पांच पंच वर्षीय योजना में जाकर पूरा होगा, इस सम्बन्ध मे किए कुछ विशेष अध्ययनों के आधार पर 2200 रु० प्रति हैक्टर खर्च आएगा। इन कार्यों के पूरा हो जाने से न केवल हिमालय क्षेत्र संरक्षित हो जाएगा उनसे स्थानीय तथा उनसे निकले नदी - नालों के किनारे नीचे के प्रदेश में बसे लोगों को भी अनेक प्रकार से लाभ पहुंचेगें।

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BIOMASS PRODUCTION IN PLANTATION ECOSYSTEM OF *AILANTHUS EXCELSA* AT FIVE DIFFERENT AGES IN UTTAR PRADESH

M.C. PANDE, V.N. TANDON AND MRIDULA NEGI
Forest Productivity,
Forest Research Institute, Dehra Dun (India)

Introduction

Ailanthus excelsa Roxb. commonly occur throughout the tropical and subtropical parts of the country. It is a strong light demander, generally absent in heavy rainfall areas and is supposed to be an excellent fodder yielding tree. Though some data on chemical composition and detailed information on silvicultural characters, nursery technique etc. (Singh, 1982) of this species is available, the data on biomass production and its distribution among various tree components is not so far, estimated.

Large scale plantation of *Ailanthus excelsa* have been raised in Mohand Range of Shiwalik Forest Division in Uttar Pradesh. The estimation of biomass production and its distribution among various component plant parts in these plantation has been discussed in this paper.

Study Area

The study area is situated at 650 m above m.s.l. (latitude between 29°-45′ N to 30°-25′ N and longitude between 77°-35′ E to 76°-10′ E) receiving an average annual rainfall between 280 mm to 307 mm and classified as Dry Shiwalik Sal Forest and Northern Dry Mixed Deciduous Forests (Champion and Seth, 1968). The soil of the area is of low quality and sandy.

Five plantations of 3, 6, 11, 16 and 21 years old were selected for the present study and the details of these plantations are given in Table 1.

Methods

A representative sample plot measuring between 0.04 to 0.09 ha (Table 1) was laid out in each plantaion and d.b.h. of all the standing trees within the plot were recorded and grouped into 3 to 5 diameter classes, depending upon the diameter range in each plantation. One mean tree from each diameter class was felled and fresh weight of each component recorded separately for estimation of biomass The roots of one sample tree (close to the mean diameter of the crop) was dug out in each plantation for estimation of under-ground biomass. Representative samples of each tree component were collected for dry weight estimation and nutrient analysis.

Results and Discussions

Individual tree dimentions : The individual sample tree in each plantation differ greatly in size and form, though they are of identical age. The D.B.H. of tree within the plot ranges between 3 cm to 14 cm, 6 cm to 17 cm, 9 cm to 18 cm, 9 cm to 20 cm and 6 cm to 14 cm at ages 3, 6, 11, 16 and 21 respectively. With regard to height growth, it shows

Table 1

Details of Ailanthus excelsa plantations

Age (Yrs.)	3	6	11	16	21
Area of enumeration plot (ha)	0.06	0.04	0.09	0.09	0.04
No. of trees on the enumeration plot	141	67	90	75	49
No. of trees/ha	2350	1675	1000	834	1225
Mean diameter of the crop (cm)	6.95 (3.0-14.0)	10.2 (6.0-17.0)	13.5 (9.0-18.0)	14.4 (9.0-20.0)	10.3 (6.0-14.0)
Class A	4.1 (3.0-5.0)	7.7 (6.0-8.0)	9.5 (9.0-10.0)	11.0 (9.0-12.0)	7.1 (6.0-8.0)
Class B	7.3 (6.0-8.0)	9.8 (9.0-11.0)	11.8 (11.0-12.0)	14.1 (13.0-16.0)	10.0 (9.0-11.0)
Class C	9.5 (9.0-11.0)	13.1 (12.0-14.0)	13.5 (13.0-14.0)	18.3 (17.0-20.0)	13.4 (12.0-14.0)
Class D	12.25 (12.0-14.0)	16.1 (15.0-17.0)	15.5 (15.0-16.0)	—	—
Class E	—	—	17.5 (17.0-18.0)	—	—
Mean height of the crop (m)	5.6	9.45	11.5	10.95	8.45
Class A	5.2	4.67	10.5	7.3	6.35
Class B	5.6	9.45	11.2	10.95	8.45
Class C	6.65	10.5	11.5	10.95	6.80
Class D	8.75	10.8	10.5	—	—
Class E	—	—	12.10	—	—

slight variation in all the diameter classes within a plantation, though there is generally some increase in height with increase in diameter. The different structures of trees of different size may result partly from genetical variations but can also be attributed to environmental and chance factors favouring certain trees initially, so that they grow relatively rapidly during the early years to attain a more favourable position which influences tree form (Ovington and Madqwick, 1959).

Organic matter in sample trees

Componentwise oven dry weight along with percentage contribution to above-ground biomass is given in Table 2. There was a considerable difference between fresh

Table 2

Dry weight by tree components of sample trees (kg/tree)

Age (Yrs.)	D B.H class	Wood	Bark	Leaf	Twig	Branch	Total	Root	Total
	A	1.03 (31.3)	0.34 (10.3)	0.07 (2.1)	0.90 (27.4)	0.95 (28.9)	3.29	0.82*	4.11
	B	4.07 (52 9)	1.52 (19.7)	0.38 (4 9)	0.84 (10.9)	0.89 (11.6)	7.70	1.93 (25.1)	9.63
3	C	7.27 (49.4)	3.44 (23.4)	0.80 (5.4)	1.20 (8.2)	2.01 (13.7)	14.72	3.69*	18.41
	D	12.55 (64.6)	3.60 (18.5)	0.59 (3.0)	0.75 (3.9)	1.95 (10.0)	19.44	4.87*	24.31
	A	6.34 (51.9)	2.33 (19.1)	0.51 (4.2)	0.81 (6.6)	2.22 (18.2)	12.21	2.73*	14.94
	B	15.02 (61.1)	5.84 (23.7)	0.58 (2.4)	0.77 (3.1)	2.39 (9 7)	24.60	5.51 (22.4)	30.11
6	C	20.30 (60.0)	7.84 (23.2)	1.04 (3.1)	1.43 (4.2)	3.20 (9.5)	33.81	7.57*	41.38
	D	33.20 (64.1)	12.51 (24.2)	0.92 (1.8)	1.43 (2 8)	3.70 (7.1)	51.76	11.59*	63.35
	A	10.26 (59.8)	4.62 (26.9)	0.14 (0.8)	0.33 (1.9)	1.80 (10.5)	17.15	3.06*	20.21
	B	22.43 (64.6)	8.42 (24.3)	0.30 (0.9)	0.96 (2.8)	2.60 (7.5)	34.11	6.20 (17.9)	40.91
11	C	24.19 (59.8)	9.62 (23.5)	0.31 (0.8)	1.40 (3.4)	5.16 (12 6)	40.98	7.32*	48.30
	D	29.76 (65.4)	10.80 (23.7)	0.29 (0.6)	0.63 (1.4)	4.00 (8.8)	45.48	8.12*	53.60
	E	42 16 (68.5)	12.84 (20 9)	0.45 (0 7)	0.77 (1.3)	5 30 (8.6)	61.52	10.98*	72 50
	A	10.38 (54 9)	4 94 (26.1)	0 55 (2.9)	0.90 (4.8)	2.13 (11.8)	18.90	3.42*	22.23
16	B	22.76 (62.8)	8.32 (22.9)	0.76 (2.1)	1.25 (3.4)	3.20 (8.8)	36 27	6.57 (18.1)	42.84
	C	43.04 (57.5)	13.44 (18.0)	0.92 (1.2)	2.40 (3.2)	15.00 (20.1)	74.80	13.55*	88.35
	A	4.73 (40.9)	3.22 (27.8)	0.57 (4.9)	0.78 (6.7)	2.27 (19.6)	11.57	2.40*	13.97
21	B	13.29 (57.5)	5.13 (22.2)	0.56 (2.4)	1.00 (4.3)	3.12 (13.5)	23.10	4.79	27.89
	C	24.90 (60.6)	8.89 (21.6)	0.93 (2.3)	0.72 (1.8)	5.64 (13.7)	41.08	8.52	49.60

Note : (i) Figures in brackets indicate the percentage of the total above-ground dry weight.
(ii) Figures marked with asterisk (*) are calculated values as root were not sampled in these trees.

weight and dry weight of sample trees. Maximum moisture loss was observed in leaves (72%) and minimum in bole (56%). The dry weight of sample trees increases with increasing diameter in each plantation. In each age group, diameter class A has the minimum biomass while diameter class C,D,E (highest diameter classes) has the maximum biomass. Considering the average total above-ground biomass of the sample trees in each age group, the biomass increases from 11.3 kg/tree (3 years) and the peak value 43.3 kg/tree is obtained at the age of 16 years.

with regard to percentage contribution of component plant parts to total above-ground biomass, bole and bark contributed maximum followed by branches, least percentage contribution was observed in leaf and twigs. This may possibly be due to biotic interferences. Leaf being an excellent fodder, is generally plucked by villagers. Negi *et al.*, 1984, while studing on *Eucalyptus globulus* have observed lesser contribution of leaf and twig and have explained the plucking of leaf along with twig for oil distillation.

As mentioned earlier, only one root was sampled in each plantation, the oven dry weight of roots of other sample trees in each plantation have been calculated on the ratio of root biomass to above-ground biomass. These calculations may not be wholly correct and may possibly be approximate. However, there is a increasing trend of root biomass with increasing age. The percentage contribution ranges between 17.9 to 25.1.

Biomass Predictions

To overcome the difficulty of felling large number of trees for getting an estimate of dry matter production of various tree components 19 sample trees, representing all diameter and hight variations in the site, were harvested to get a set of regression equations between dry matter production and easily measurable parameters (D.B.H. and height). These can be utilized to predict biomass values for this region.

The following models have been tried :

$$Y = a + b X \quad \text{.................} \quad (A)$$

$$\text{Log } Y = a + b \log X \quad \text{...........} \quad (B)$$

Where Y is the biomass component, X is D^2H and D.B.H. and 'a' and 'b' are regression constant and coefficient respectively.

In all these regression equations D.B.H. and D^2H (square of D.B.H. × Height) have been used as the independent variables and the tree components as dependent variables. There has been significant correlation between them except in the case of leaf weight and the twig weight. The exception in these cases can possibly be attributed due to the biotic interference, the leaves of *Ailanthus excelsa* were stated to be badly lopped for the fodder in this area.

Following tables give the details of the linear and log linear regression equations.

Table 3

Table showing the linear regression Equations and Coefficients of Correlation for the variable D^2H with other characters

Variables (Y)	Equations ($Y = a + b X$)	Correlation coefficient (r)	Level of significance
Bole weight	$Y = 2.0678 + 0.0110\ D^2H$	0.9714	***
Bark weight	$Y = 1.6855 + 0.0034\ D^2H$	0.9665	***
Leaf weight	$Y = 0.4457 + 0.0001\ D^2H$	0.3073	N S.
Twig weight	$Y = 0.7031 + 0.0002\ D^2H$	0.5190	N.S.
Branch weight	$Y = 0.5918 + 0.0020\ D^2H$	0.7165	*
Total weight	$Y = 5.4928 + 0.0167\ D^2H$	0.9605	***
Root weight	$Y = 1.6041 + 0.0030\ D^2H$	0.9356	***
Total Biomass	$Y = 7.0969 + 0.0197\ D^2H$	0.9590	***

Where D is the Diameter at breast height and H is the Height.
*** Indicate significance at 0.1% level of probability.
* Indicate significance at 5% level of probability.
N.S Not significant even at 5% level of probability.

Table 4

Table showing the linear regression Equations and Coefficients of Correlation for the variable D.B.H. (X) with other character.

Variables (Y)	Equations ($Y = a + b X$)	Correlation coefficient (r)	Level of significance
Bole weight	$Y = -18.5859 + 3.1645\ X$	0.9563	***
Bark weight	$Y = -4.9470 + 1.0004\ X$	0.9509	***
Leaf weight	$Y = 0.1684 + 0.0336\ X$	0.4556	N.S.
Twig weight	$Y = 0.3571 + 0.0561\ X$	0.4771	N.S.
Branch weight	$Y = -3.0989 + 0.5705\ X$	0.6976	*
Total weight	$Y = -26.1085 + 4.8254\ X$	0.9497	***
Root weight	$Y = -4.2335 + 0.8758\ X$	0.9466	***
Total Biomass	$Y = -30.3421 + 5.7012\ X$	0.9516	***

Where *** Indicate significance at 0.1% level of probability.
* Indicate significance at 5% level of probability.
N.S. Not significant even at 5% level of probability.

Table 5

Table showing the log linear regression Equations and Coefficients of Correlation of the variable D^2H with other variables

Variables (Y)	Equations (Log Y = a + b log X)	Correlation coefficient (r)	Level of significance
Bole weight	Log Y = —3.7768 + 0.9190 log D^2H	0.9742	***
Bark weight	Log Y = —4.3097 + 0.8580 log D^2H	0.9482	***
Leaf weight	Log Y = —3.0827 + 0.3361 log D^2H	0.4825	N.S.
Twig weight	Log Y = —0.9465 + 0.1265 log D^2H	0.3045	N S.
Branch weight	Log Y = —2.4895 + 0.5097 log D^2H	0.7864	**
Total weight	Log Y = —2.0855 + 0.7577 log D^2H	0.9677	***
Root weight	Log Y = —3.0866 + 0.6745 log D^2H	0.9557	***
Total Biomass	Log Y = —1.7964 + 0.7432 log D^2H	0.9675	***

Where D is the Diameter at breast height and H is Height.
*** Indicate significance at 0.1% level of probability.
** Indicate significance at 1% level of probability.
N.S. Not significant even at 5% level of probability.

Table 6

Table showing log linear regression Equations and Coefficients of Correlation of D.B.H. (X) with other characters.

Variables (Y)	Equations (Log Y = a + b log X)	Correlation coefficient (r)	Level of significance
Bole weight	Log Y = —3.3547 + 2.4823 log X	0.9780	***
Bark weight	Log Y = —3.9039 + 2.3126 log X	0.9499	***
Leaf weight	Log Y = — 3.3477 + 1.0827 log X	0.5778	N.S.
Twig weight	Log Y = —0.9558 + 0.3698 log X	0.3309	N.S.
Branch weight	Log Y = —2.3662 + 1.4231 log X	0.8160	**
Total weight	Log Y = —1.7411 + 2.0481 log X	0.9722	***
Root weight	Log Y = —2.8241 + 1.8415 log X	0.9698	***
Total Biomass	Log Y = —1.4658 + 2.0120 log X	0.9735	***

Where *** Indicate significance at 0.1% level of probability.
** Indicate significance at 1% level of probability.
N.S. Not significant at 5% level of probability.

As can be seen from above tables the model log Y = a + b log X, where independent variable X is d.b.h. gives comparatively better predications. Hence this model can be utilized for predication purposes.

Total Biomass

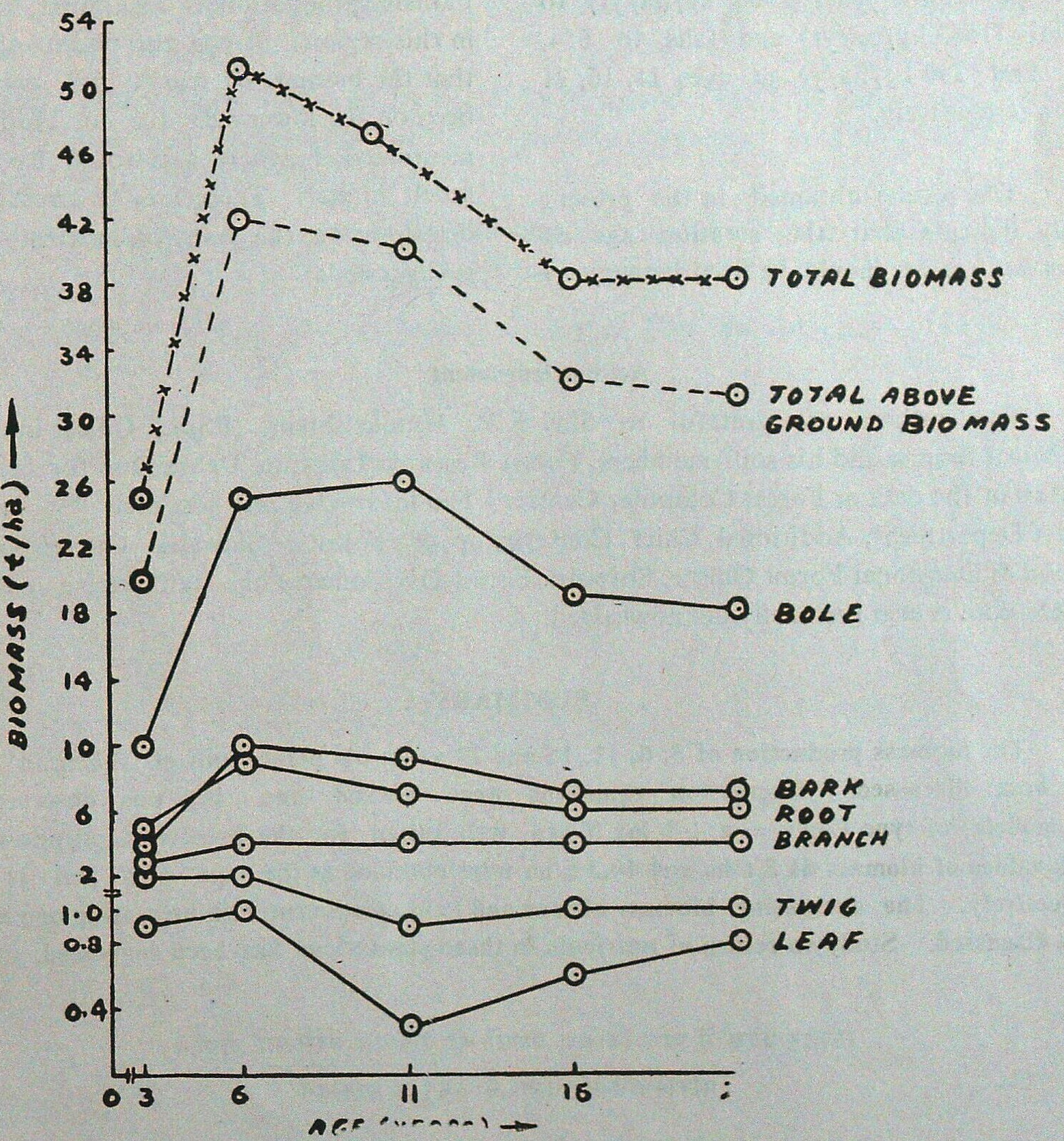
Sample tree data has been used to calculate the biomass on a per hactere basis at different ages and is given in Table 7 and Fig. 1. The above-ground biomass of these plantations ranges between 19996 kg/ha and 41896 kg/ha. The biomass increases sharply from 3 years to 6 years of age and thereafter decreases gradually with increasing age and suddenly decline after 11 years of age. Similar trend is observed in case of bole biomass, where maximum value is obtained at the age of 11 years. Other component plant part did not exhibit any definite trend. Minimum biomass accumulation is observed in leaf (between 301 kg/ha and 1105 kg/ha) and twig

Table 7

Total standing biomass (kg/ha) at different ages.

Age (Yrs.)	3	6	11	16	21
Bole	9990 (50.0)	25209 (60.2)	25794 (64.1)	18927 (59.4)	17852 (57.0)
Bark	3988 (19.9)	9636 (23.0)	9372 (23.3)	6854 (21.5)	7074 (22.6)
Leaf	913 (4.6)	1105 (2.6)	301 (0.7)	602 (1.9)	828 (2.6)
Twig	2215 (11.1)	1592 (3.8)	896 (2.2)	1129 (3.5)	1049 (3.4)
Branch	2898 (14.5)	4354 (10.4)	3898 (9.68)	4342 (13.6)	4491 (14.4)
Total above-ground biomass	19996	41896	40261	31854	31294
Root	5008 (25.0)	9380 (22.4)	7189 (17.9)	5769 (18.1)	6490 (20.7)
Total biomass	25004	51276	47450	37623	37784
Productivity (kg/ha/yr)					
Non-photosynthetic above-ground biomass	6361	6799	3633	1953	1451
Non-photosynthetic root biomass	1669	1563	654	361	309
Total	8030	8362	4287	2314	1760

Fig. 1



Total standing biomass of *Ailanthus excelsa* at different ages.

(between 896 kg/ha and 2215 kg/ha). The poor accumulation of these components has already been explained. Considering the percentage contribution of component plant parts to total above-ground biomass, bole contribute more than 50% followed by bark, 19.9% to 23.3% and branches 9.68% to 14.5%. The percentage contribution of roots ranges between 18.1% to 25.0%.

The rate of accumulation of dry matter (Table 4) in the non-photosynthetic tree components increases from 3 years (6361 kg/ha/yr) to 6 years (6799 kg/ha/yr) and thereafter sharply declines. The non-

photosynthetic root biomass gradually decreases from 3 years (1669 kg/ha/yr) to 6 years (1563 kg/ha/yr) and falls to 654, 361 and 309 kg/ha/yr at ages 11, 16, 21 years respectively.

The results obtained in the present study indicate that the rotation age of *Ailanthus excelsa* should be fixed between 11 and 16 years of age, where the average biomass production is maximum, at least in this region. It has also been observed that the biomass of leaves and twigs has been on the lower side due to lopping as mentioned elsewhere and would have been much higher. Therefore, to arrest the site deterioration, the study on nutrient cycling is suggested.

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SUMMARY

The biomass production of 3, 6, 11, 16 and 21 years old plantations of *Ailanthus excelsa* has been discussed. Regression equations were worked out, it was observed that log models of type Log y = a + b log X are well suited for the prediction purposes. The peak values of biomass 41 8 t/ha and 40.3 t/ha were obtained at the age of 6 and 11 years respectively. The decreasing biomass of leaf and twig component with increasing age has also been discussed. Study on return of nutrients in these plantations has been suggested.

उत्तर प्रदेश में पांच विभिन्न वयसों की ऐलेन्थस एक्सेल्सा रोपवन परिस्थिति-संहतियों में जैवपुंज उत्पादन

एम०सी० पाण्डे, वी०एन० टंडन व मृदुला नेगी

सारांश

इस अभिपत्र में 3, 6, 11, 16 और 21 वर्षीय ऐलेन्थस एक्सेल्सा रोपवन के जैवपुंज उत्पादन का विवेचन किया गया है। इसके प्रतीपायप समीकरण भी बनाए गए। जिससे यह देखने में आया कि लॉग Y=a+b लॉग × प्रकार के लॉग प्रतिरूप भविष्य का अनुमान बताने के लिए बहुत उपयुक्त रहेंगे। जैवपुंज की शिखर अर्हा 41.8 टन/हेक्टे०, 40.3 टन/हैक्टे० क्रमशः रोपवन की उम्र 6 और 11 वर्ष होने पर प्राप्त हुई। उम्र बढ़ती जाने के साथ पत्तियों और टहनियों के जैवपुंज के घटने के कारणों का विवेचन किया गया है। इन रोपवनों में पोष्याहारों की वापसी का भी अध्ययन होना चाहिए—यह सुझाया गया है।

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SILVICULTURAL SYSTEMS IN THE TROPICAL RAIN FORESTS OF KARNATAKA

K.A. KUSHALAPA*

Research and Utilization Circle, Bangalore (Karnataka)

Introduction

The Tropical Wet Evergreen Forests of Karnataka (India) are in the tropical belt extending as a narrow strip of about 400 km long and about 25 km wide from Makut (Kodagu district) in the extreme Sount (11° 50′ N Lat.), to Kankumbi (Belgaum district) in the extreme North (15° 45′ N Lat). They are also often termed as "Tropical Rain Forests" and these well developed forests occur in areas receiving rainfall of 2500 mm and above. It forms about 15% of the total area of forests (20%) of Karnataka. The Tropical Rain Forests mostly occupy the lower slopes on either side of the Western Ghats—a continuous hill range extending from South to North along the West Coast of Southern India. On the Eastern slope, the Tropical Rain Forests occur at lower altitudes compared to Western slopes of the Western Ghat where they occupy higher elevations. The terrain is generally steep often precipitous. The top (ridge) of the Western Ghats contain extensive grass lands due to high velocity wind and annual fires.

The Western Ghat receives South-West monsoon rains from June to October and has 5 months of dry season. The maximum rainfall is recorded in Agumbe (7000 mm) situated at an elevation of 1200 m and has extensive Tropical Rain Forests. The temperature variation is not much (5 to 6°C) and the maximum shade temperature may be not more than 26°C. The humidity rarely falls below 80%.

The laterite soils are characteristic of the Tropical Rain Forests of Western Ghats and are developed mainly from the basic rocks. They are usually aceolic (pH 5 to 6), poor in mineral nutrients and have a low silica sexquioxide ratio (Yadav, 1981). The Table 1 gives the soil profile analysis data of both grass lands and Tropical Rain Forests of soil of Western Ghats. Nutrients status of Western Ghats are described by Singh (1968).

On red soils derived from decomposition of granite/gneiss or lateritic in high rainfall area, the Tropical Rain Forest type is predominantly seen (Arora, 1960).

The distribution of different type of forests in the Western Ghat is governed by climatic and soil factors. In Belgaum division, small areas come under evergreens due to favourable conditions of soil and moisture and are believed to be postclimax within semi-evergreen and excluded from working and resemble some of the pri-

* Presently Conservator of Forests, Mysore Circle, Mysore (Karnataka).

Table 1

The soil profile analysis of typical areas in Tropical Rain Forests of Karnataka

Locality	pH	Organic Carbon (%)	Clay (%)	Silt (%)	Coarse (%)	Fine (%)
Bhagamandla Grassy blank)	5.9	0.75	16.9	9.3	41.3	32.6
Bhagavathy (Grassy blank)	6.0	1.15	16.1	18.1	29.7	36.1
Agumbe (Forest)	5.6	1 08	24.3	8.9	36.8	30.0

mordial forests with lofty trees of evergreen species (Jagadishchandra, 1968). Some evergreen patches in Gund area of Haliyal division are due to microclimate and edaphic climax) Viswanath, 1972).

Floristics

It is difficult to find out a typical and well developed example of Tropical Rain Forests in Karnataka except in few isolated patches where the vegetation is still intact. The most widely distributed families are : (i) Guttiferae with genera such as *Galophyllum, Poeciloneuron, Mesua, Garcinia, Ochrocarpus* (ii) Anacardiaceae with genera such as *Gluta, Mangifera, Spondias, Solenocarpus, Semecarpus, Buchanania, Holigarna* (iii) Sapotaceae with genera such as *Chrysophyllum, Palaquium, Mimusops, Bassia, Sideroxylon,* (iv) Meliaceae with genera such as *Dysoxylon, Aglaia, Amoora, Toona* (v) Leguminosae with genera like *Dalbergia, Acrocarpus, Hardwickia.*

The species like *Dipterocarpus, Chrysophyllum* and *Diospyros* have restricted distribution. The top storey consists of *Dipterocarpus indicus, Calophyllum elatum, C. wightianum, Hopea wightianum, Holigarna arnottiana, H. grahamii, Lophopetalum wightianum, Polyalthia coffeoides, Machilus macrantha, Mangifera indica, Chrysophyllum roxburghii, Cinnamomum zeylanicum, Syzigium gardneri, Artocarpus hirsuta, Mimusops elengi, Diospyros ebenum, Poeciloneuron indicum.*

The middle storey consists predominantly of families like Myrtaceae and Lauraceae with other species like *Euphoria longana, Aglaia roxburghiana, Garcinia indica, Symplocos spicata, Aporosa lindleyana, Litsea* spp., *Bassia longifolia, Caryota urens, Knema attenuata.*

Bamboos are relatively rare in the climax type but the undergrowth consists of *Strobilanthes* (several species), *Pyschotria* sp , *Ixora, Canthium didymum, Leea sambucina* etc. Canes and Lianes such as *Enteda scandens* are common. Each species may account for 2 to 3% only. The top canopy associations are dominated by relatively few species, especially *Hopea, Cullenia, Palaquium, Poeciloneuron, Calophyllum,*

Dipterocarpus, *Vateria* and *Mesua*. The species characteristic of edaphic varieties are *Elaeocarpus*, *Lophopetalum*, *Hopea wightiana* and *Ochlandra*.

Silviculture Systems

Tropical Rain Forests are sensitive to disturbances. In an unworked forests, all age gradations are completely mixed up, with no species representing more than 2%. The Silviculture systems prescribed in the Working Plans aim at removing unsound and mature trees not only for meeting the demands of people but also to encourage advance growth and young regeneration. Most of the species are sensitive to large openings and therefore judicious removal is necessary. If the openings are large, several light demanding species like - *Macaranga peltata*, *Trema orientalis* quickly occupy the area preventing numerous other species (which are at present more valuable) to come up. Therefore, selection system of fellings are prescribed in all the Tropical Rain Forests of Karnataka with few exceptions. There are slight modifications from the text book pattern of selection system. The text book pattern involves removal of trees singly over the entire area every year. But in order to concentrate the fellings in a specific area, the forests areas are grouped into felling series and the removal from each area is in a cycle. The felling cycle depends upon the species, the rate of growth, thepercentage of higher girth (exploitable girth) classes, the time required for trees to pass from lower girth class to the exploitable irth class, etc. The felling cycle in the Tropical Rain Forests of Karnataka range from 30 to 45 years.

The approximate extent of Tropical RainForests in Karnataka is about 570,000 ha of which about 221,000 ha (38%) are under selection or selection-cum-improvement system of working. Though few of the areas are indicated as under selection system, it is infact Selection-cum-improvement system in the sense, the objectives are to improve the composition of the crop through selection. Dead, dying and overmatured trees are first marked for felling.

In all selection areas, the subsidiary silvicultural operations consist of tending by freeing the group of seedlings from suppression by weeds, reeds, climbers and inferior species (Somaiah, 1959). This will be done one year after the extraction of timber.

The grass lands on the ridges and slopes of the Western Ghats and forests on steep and inaccessible areas where extraction is difficult and liable for accelerated soil erosion are put under complete protection. No extraction is prescribed, except afforestation of grasslands with successful species like - *Acacia auriculiformis*, *Acrocarpus fraxinifolius*, *Grevillea robusta*, *Casuarina equisetifolia*, *Bambusa vulgaris*, *Bixa orellana* etc, (Rai and Shettigar, 1979) which are hardy and can tolerate adverse conditions like insolation, competition from tall grasses and heavy wind. The nutrient status is poor (pH 5.0) hence lot of input in the form of Phosphates and Nitrates are required for better survival and success of plantation. The area set apart for protection is about 290,000 ha forming nearly 51% of the total area of the Tropical Rain Forests. In view of the present heavy demand for fuelwood and timber, it is now contemplated to extract dead and fallen trees from these areas though the cost is prohibitive.

About 13,000 ha (2%) are subjected to tending operation where the dense natural regeneration of miscellaneous species prevents the establishment of other more valuable species. In these areas the underwood of economically less useful species upto 10 m height are felled judiciously including clearing of ground flora and climber cutting before the onset of monsoons, so that the natural regeneration of useful species are allowed to establish. If there are some large trees of species like—*Ficus nervosa*, they are girdled to kill and deteriorate. These gradual openings will promote natural regeneration of other favoured species. This method of 'Canopy lifting' and tending was extensively practised in Tropical Rain Forests of Agumbe and surrounding areas with good success (Sharma, 1965). The species that have come up in tended areas are *Dipterocarpus indicus*, *Poeciloneuron indicum*, *Dichopsis elliptica*, *Elaeocarpus tuberculatus*, *Simplocos spicata* etc. However, the area of annual working has been reduced considerably due to the complexity of forest ecosystem, which if not tended carefully and properly, would result in completely upsetting the species diversity.

In the working of Tropical Rain Forests, special emphasis is also given to favour certain presently valuable species like *Poeciloneuron indicum* in Koppa division *Hopea parviflora* and *Vateria indica* in Kundapur division. Separate prescriptions are given to open the forest canopy heavily to promote light demanding species like *Hopea parviflora* and *Vateria indica*. Heavy fellings of this nature in Makut forests of Madikeri division have resulted in pure patches of the above two species. Natural gaps however will be artificially planted up with *Hopea* or *Vateria* species. *Poeciloneuron indicum* appears in pure patches with profuse natural regeneration in Bhagavathy Valley of Koppa division due to edaphic factors This species being more favoured as poles, sleepers and construction wood, it is preferred by special prescriptions.

Large areas (15,000 ha) were leased out for Cardamom cultivation in Madikeri division around 1920 The constant manipulation of canopy and clearing of undergrowth to favour Cardamom have eliminated young regeneration of tree species, where only large trees are standing at present It is now difficult to naturally regenerate these areas to bring back to their orginal composition. The cultivation of Cardamom is now prevented in such areas and it is proposed to gradually remove the overwood to promote natural regeneration. The area under such specific treatment to favour a single species is only about 3%.

Several degraded patches of Tropical Rain Forests in Kundapur, Mangalore and Madikeri divisions have been enriched by taking up softwood plantations with species such as *Ailanthus malabaricum*, *Bombax ceiba* and *Evodea roxburghii* covering in all about 6000 ha (about 1%).

Separate prescriptions are also laid out in the Tropical Rain Forests to extract canes and reeds as an overlapping working with other systems It extends over 101,000 ha forming nearly 18% of the total area of the Tropical Rain Forests in Karnataka

Yeild

In the selection system of working in the Tropical Rain Forests in Karnataka, the yeild was normally worked out using Smythies safeguarding formula (Mathur, 1968).

In the absence of sufficient data, the rate of growth is assumed, to arrive at the number of trees pass from the penultimate girth class to exploitable girth class and thereby fixing the number of trees to be removed per ha. In this process if there are large number of trees of penultimate and exploitable girth classes, more number trees per ha would be removed annually. This will not take into account the actual regeneration status of younger age classes in the forests and hence not a very sound proposition. The recruitment is always scanty in these forests due to various reasons. The working plans of different divisions show the number of trees prescribed for removal, and they vary from 10 to 1 trees/ha. However, in a recent decision of Government, the removal is restricted to maximum 7 trees per ha in all the areas. The yeild is now controlled by number of trees as well as area.

In Sirsi, Siddapur Ranges (Kanara Forests) the exploitable size for softwoods is 1.83 m girth at breast height. However *Calophyllum elatum* and *Dipterocarpus indicus* are exploited when the attain 2.13 m girth. Several other species are marked when they attain 1.22 m girth, due to poor rate of growth and deterioration of bole beyond that girth. Such species are *Mangifera indica, Machilus macrantha, Canarum strictum, Syzygium cuminii, Tetrameles nudiflora, Toona ciliata, Dysoxylon malabaricum, Lophopetalum wightianum* and *Calophyllum wightianum* (Thippeswamy, 1961).

Regeneration

In the Tropical Rain Forests where there is dearth for natural regeneration of all favoured species, the working plan prescribed dibbling of seeds of important ever-green species, soon after extraction and during the ensuing rains in June. Some Working Plans have prescribed under-planting in strips or gap planting to enrich the forests with valuable species having demand. The natural regeneration of other species will be so vigorous that by the time the planted species recover from the planting shock and establishes, it gets completely overtopped. It will be difficult during rainy season to take up weeding and clearing around planted species due to remoteness and steepness of the area, hence almost impossible to monitor the success of planted species. Even dibbled seeds get smothered before they germinate and establish. Therefore, in many areas of Tropical Rain Forests this practice is also given up.

Grazing incidence by cattle from the nearby village is so heavy that most of palatable species are browsed leaving unpalatable and useless species. The movement of cattle hardens the soil preventing germination and establishment of many species. In certain areas there are certain privileges which will further damage the saplings and pole crop due to hacking for the use of villagers. The investment per ha is also comparatively meagre in these forests resulting in poor regeneration and establishment of favoured species. Works like weeding, tending, climber cutting etc., leaves the composition, ecologically least desirable.

Future Strategy

In order to maintain the complexity of Tropical Rain Forests and their species diversity, an ecologically sound management is desirable with minimum disturbance. This

is however not an economically sound proposition, therefore only fragile and sensitive areas should be set apart as protection areas or biosphere reserves to serve as bench marks for monitoring the status for other worked areas. It is reported that about 6000 ha in Bhagamandala range, the evergreen forests have changed to deciduous type due to extensive Kumri cultivation (Somaiah, 1959). Areas which are not prone to ecological disasters due to extraction etc., be worked rather heavily to promote the regeneration of favoured species to meet the demands of people. Periodical studies on soil and regeneration status of species should be carried out to alter the management prescriptions wherever necessary. The extensive grasslands coming under the Tropical Rain Forest areas should be planted up with suitable tree species or fodder grass/legume to replace the present coarse grass, not only to prevent summer fires but also to increase the productivity of the area. In order to take up such intensive management and studies, it is necessary to establish a full-fledged Tropical Rain Forest Research Institute so that most of the complex problems, that eludes a solution at present, be tackled more systematically and scientifically to achieve our desired objectives.

SUMMARY

The Tropical Evergreen Forests of Karnataka are ecologically very sensitive to disturbance. Heavy openings will create large gaps and will soon be invaded by species like—*Macaranga peltata* and *Leea sambucina*. The forests are situated on steep slopes in heavy rainfall zone. Therefore, selection system has been adopted in about 38% of the area. The grasslands on the ridges and slopes of the Western Ghats and forests on steep and inaccessible areas are put under protection working circle which covers an area of about 51%. However, in grasslands, afforestation with species like — *Acacia auriculiformis, Crevillea robusta, Bambusa vulgaris* and *Bixa orellana* have been successful. About 2% of the area were tended by way of "canopy lifting" to induce regeneration of more valuable species, but is now given up due to the complexity of this forest ecosystem. The management of Tropical Rain Forests requires complete knowledge about the growth of species, their interaction between species and between soil and plants. Therefore, the establishment of a Tropical Rain Forest Research Institute has been suggested.

कर्नाटक के उष्णदेशीय वर्षा वनों की वन संवर्धन प्रणालियां

के०ए० कुशलप्पा

सारांश

कर्णाटक के उष्णदेशीय सदाहरित वन हस्तक्षेप के प्रति बहुत अधिक सुकुमार हैं। वनों को अधिक खोलने से उनमे बड़े-बड़े चीड़ वन जाएंगे और बहुत जल्दी उनकों मैकेरेंगा पेल्टेटा और लीआ सैम्बुसिना जैसी जातियां आक्रान्त कर डालेंगी। ये वन भारी वर्षा होने वाले प्रदेश अधिक ढलवां ढलानों पर लगे हैं। इसी कारण इस क्षेत्र के लगभग 38% क्षेत्र में चयन प्रणाली अपनाई गई है। पश्चिमी पहाड़ियों के कूटों और ढालों की

घास-भूमियों और अधिक ढलवां एवं अगम्य वनों को रक्षा वन वृत्तों में रखा गया जिसमें लगभग 51% क्षेत्र आता है। तथापि घास-भूमियों में कुछ वृक्ष जातियां जैसे अकेमिया औरिकुलीफार्मिस, ग्रेविलिया रोबस्टा, बैम्बुसा वलगैरिस और बिक्सा औरेलाना से वनीकरण भी सफल रहा है। क्षेत्र के 2% भाग की देख-रेख "वितान उठाने" से की गई ताकि इसमें अधिक मूल्यवान जातियां पुनर्जनित हो सकें परन्तु यह प्रणाली अब इस क्षेत्र की जटिल परिस्थिति-सहति को देखते हुए छोड़ दी गई है। उष्णदेशीय वर्षा वनों का प्रबन्ध करने के लिए वृक्ष जातियों की वृद्धि, वृक्ष जातियों में परस्पर इसकी क्रिया–प्रतिक्रिया तथा पादकों और मृदा में क्रिया-प्रतिक्रिया की पूरी जानकारी अपेक्षित होती है। इसी कारण से उष्णदेशीय वर्षा वन अनुसंधान संस्थान बनाने का सुझाव दिया गया है।

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COMPARATIVE VEGETATION ANALYSIS OF SOME PLANTATION ECOSYSTEMS

P K. PANDE,* A.P.S. BISHT AND S.C. SHARMA

Forest Ecology Branch,

Forest Research Institute, Dehra Dun (India)

Introduction

The fast depleting forest land has not only affected the economic structure of the country but also deteriorated the environment. To restore this, there is an urgent need to cover the land with vegetation. The plantation ecosystem, monoculture or mixed one, develops to a mature stand in due course of time. A number of new species, depending upon the management practices, invade the stand during the course of plantation growth. This quantitative growth of forest stand determines their structure, composition, pattern of distribution and diversity. Variations of the quantitative growth are associated with differences of site conditions (edaphic and climatic factors), dynamics of regeneration, growth and succession of biotic impacts (Brunig, 1971; Brunig *et al.*, 1979).

Though, some studies were undertaken on the quantitative analysis in natural forests of different climatic zones (Monk, 1967; Knight, 1975; Saxena *et al.*, 1978; Pandey and Singh, 1981 a and b; Saxena and Singh, 1980 & 82). Little information on this aspect is available for man-made ecosystems (Srivastava, 1986). Therefore, an attempt has been made in this direction in the present study.

The Site-Characteristics

The studies were carried out at demonstration area of New Forest, Dehra Dun stituated at Long. 77°-52′-12″; Lat. 30°-20′-4″ with an altitude of 640 m above m.s.l. The average annual rainfall and mean temperature for 1960–1984 were 2042.4 mm and 20°C, respectively. The other important features of the sites are given in Table 1.

Table 1

Characteristics of the plantations

Name of plantation	Year of plantation	Average d.b.h. of trees (cm)	No. of trees ha^{-1}	Soil-texture
P. roxburghii	1926	38.12	385	Silty clay loam
T. grandis	1926	28.80	410	Clay loam
S. robusta	1926	26.97	700	Loam
Eucalyptus spp.	1972	9.10	1700	Clay loam

* Presently at Wood Anatomy Branch.

Material and Methods

The phytosociological studies were conducted during August, 1982 by using quadrat mathod (size of quadrat was 10 m × 10 m for trees; 5 m × 5 m for shrubs and 1 m × 1 m for herbs). The site of sal and pine plantations consisted of 20 running quadrats, while 10 running quadrats were laid in teak and eucalypts plantations. In each quadrat, g.b.h. (girth at breast height at 1.37 m above-ground level) of each tree (⩾10 cm g.b.h.) was measured and recorded individually. Individuals < 10 cm g.b.h. were recorded under shrubs and herbs. Tree seedlings were considered as herbs, while saplings as shrubs. Quantitative analysis of vegetation for frequency, density and abundance was done according to the formula given by Curtis and McIntosh (1950). Relative values of frequency, density and dominance were calculated following Misra (1968) and were summed to get importance value index (IVI). The abundance to frequency ratio (A/F) for different tree species was determined for eliciting the distribution patterns. This ratio indicates regular (0.025), random (0.025-0.05) and contagious (0.05) distribution (Curtis and Cottom, 1956), Similarity index (Community index) between different plantations was calculated as per Jaccard (1912). Diversity of different plantations was determined by using 'Shannon-Wiener information function' (H) (Shannon & Wiener, 1963).

$$H = \sum_{i=1}^{S} (Ni/N) \log_2 (Ni/N)$$

Where Ni is the total number of individuals of species i, S in the number of species and N is the total number of individuals of all species in that plantation. The calculations were done in three sets; firstly, the density of all the species (including trees, shrubs and herbs) was taken into consideration secondly, the same was taken for only tree and shrub species, and thirdly, the value of IVI of tree species were used instead of density for the above calculations.

Concentration of dominance (cd) was measured by Simpson's index (Simpson, 1949).

$$cd = \sum_{i=1}^{S} (Ni/N)^2$$

Where Ni, S and N are the same as for Shannon-Wiener information functions.

Results

Vegetation analysis and distribution patterns : Table 2 reveals that total density of shrub and herbaceous species was highest in sal plantation followed by pine, teak and eucalypts. The order of richness of both these shrubby and herbaceous species in plantations was : pine> sal> teak> eucalypts. *Murraya koenigii* was present in all the plantations excepting that of eucalypts. Besides, *Urena lobata*, *Lantana camara*, *Clerodendron viscosum*, *Litsea glutinosa* were the characteristic undergrowth species of sal, teak and pine platations, while *Jasminum multiflorum* was common between sal and teak plantations. In eucalypts plantation *Achyranthes aspera*, *Adiantum capillus-veneris*, *Oxalis acetosella*, *Desmodium pulchellum*, *Oplismenus compositus* were common among herbs and *Lantana camara* as shrub. The analytic chracters of tree species in all the plantations are set in Table 3. In this regard, sal and eucalypts plantations were monospecific. The tree species *Mallotus philippensis* was common to the plantations of pine and teak with their respective IVI values 44.30 and 16.11. The other common species in pine and

teak plantations were *Syzygium cumini*, *Cinnamomum camphora* with their IVI's 10.33, 48.16 and 54.31, 6.41, respectively. Species like *Michelia champaca* (IVI) 43.16 and *Flacourtia ramontchi* (IVI) 10.55 were other tree associates in pine plantations, while only *Flacourtia ramontchi* (IVI, 6.23) in teak plantation was present (Table 3).

The total basal cover (cm^2 100 m^{-2}) was the highest for pine plantation (5308.23) and the lowest for eucalypts (1106.88), while teak (2887.27) followed sal (4002.21). The mean basal area (cm^2 $tree^{-1}$) was in order of pine (1441.89) > teak (652.38) > sal (571.75) > eucalypts (65.11) in their respective plantations. The IVI was the highest for eucalypts and sal (300) followed by teak (203.18) and pine (142.61). Abundance to frequency ratio (A/F) was 0.1 in all the plantations excepting pine, where it ranged in between 0.032–0.20 for different tree species (Table 3).

Similarity Index (*Community Coefficient*) : The similarity index between different plantations are set in Tables 4 and 5. Perusal of Table 4 indicates that similarity between different plantations ranged between 0 to 36 60%. The similarity was comparatively more among three plantations of teak, sal and pine, whereas eucalypts plantation was quite dissimilar to the others. A subtle increase was observed in similarity index between teak and sal plantations (37.48%), when density values of herbs were excluded (Table 4 & 5). While, considering IVI values of only tree species in calculations, a remarkable dissimilarity was observed among the different plantations (Table 5).

Species Diversity Index (*H*) *and Concentration of Dominance* (*cd*) : The species diversity was maximum in pine, while minimum in eucalyptus stand on density and IVI basis. The diversity index in pine stand was higher on both density basis (includes herbs, shrubs and trees) and IVI basis (includes only trees).

The values of concentration of dominance (cd) on density basis (including herbs, shrubs and trees) was highest for eucalypts and lowest for sal, while teak followed pine. However, the order of importance of cd was : eucalypts > teak > sal > pine, when excluding herbs from the calculation. On the basis of IVI of trees only, cd value was highest for both eucalypts and sal, whereas teak followed by pine (Table 6).

Discussion

Comparatively higher density values and species richness in the plantations of pine, sal and teak appear to be reflection of the maturity of the stand. It was reported that in early pine stage (30-60 years) ground layer richness stabilized at about 60% of maximum levels, but number of woody species continue to increase, while herb species decline during succession. Somewhat later in the pine periods (70 years) shrubs and understorey attained their maximum richness (Nicholson and Monk, 1974). Increase in shrubby species then herbs and stabilization of hardwood tree species under pine stand in the present study also supports the above view (Table 6).

Moreover, *Tectona grandis* and *Pinus roxburghii* had shown lack of their natural regeneration under the present climatic conditions as indicated by absence of their sapling and seedling (Table 2). This

Table 2

Phytosociological studies of some plantations (only for shrubby and herbaceous layer)

Name of species	Name of plantation											
	Pinus roxburghii			*Tectona grandis*			*Shorea robusta*			*Eucalyptus* spp.		
	A	B	C	A	B	C	A	B	C	A	B	C
1	2	3	4	5	6	7	8	9	10	11	12	13
Shrubby layer												
Achyranthes aspera	—	—	—	1.00	50	2.00	—	—	6	—	—	—
Albizia procera	0.30	15	2.00	—	—	—	0.70	45	1.50	—	—	—
Calamus tenuis	0.10	10	1.00	—	—	—	—	—	—	—	—	—
Cinnamomum camphora	0.20	55	3.63	0.10	10	1.00	1.90	70	2.80	—	—	—
Clematis gouriana	0.25	15	1.66	—	—	—	0.15	15	1.00	—	—	—
Clerodendron viscosum	7.90	90	8.42	7.90	100	7.90	13.80	100	13.80	—	—	—
Coffea bengalensis	—	—	—	—	—	—	6.40	85	7.10	—	—	—
Desmodium pulchellum	0.90	15	6	—	—	—	—	—	—	—	—	—
Echinocarpus spp.	0.30	30	1.00	—	—	—	0 20	10	2.00	—	—	—
Eupatorium tingens	0.95	10	9.50	—	—	—	—	—	—	—	—	—
Jasminum multiflorum	—	—	—	1.90	50	3.80	12.70	95	13.10	—	—	—
Lantana camara	0.85	35	2 43	0.50	30	1.66	0.15	15	1.00	8.40	100	8.40
Litsea glutinosa	0.30	20	1.50	2.30	70	3.30	7.80	100	7.80	—	—	—
Mallotus philippensis	0.65	40	1.62	0.50	50	1.00	2.60	80	3.10	—	—	—
Marlea begoniaefolia	0.20	10	2.00	—	—	—	0.05	5	1 00	—	—	—
Michelea champaca	0.80	50	1.60	0.20	20	2.00	1.80	70	2.70	—	—	—
Murraya koenigii	3.85	100	3.85	3.40	100	3.40	8.30	100	8.30	—	—	—
Morus alba	0.05	5	1.00	—	—	—	0.05	5	1.00	—	—	—
Rauwolfia serpentina	0.05	5	1.00	—	—	—	0.20	10	2.00	—	—	—
Shorea robusta	—	—	—	—	—	—	4.00	85	4.30	—	—	—

(*Contd...*)

1	2	3	4	5	6	7	8	9	10	11	12	13
Sida rhombifolia	0.10	5	2.00	—	—	—	—	—	—	—	—	—
Syzygium cumini	0.75	35	2.13	0.50	30	1.66	1.40	60	2.30	—	—	—
Urena lobata	0.45	25	1.80	0.50	30	1.00	2.70	75	3.00	—	—	—
Vallaris solanacea	0.90	15	6.00	—	—	—	—	—	—	—	—	—
Herbaceous layer												
Achyranthes aspera	2.60	50	5.20	4.10	90	4.50	—	—	—	0.50	50	1.66
Adiantum capillusveneris	—	—	—	—	—	—	—	—	—	4.50	60	7.50
Cinnamomum camphora	—	—	—	0.10	10	1.00	—	—	—	—	—	—
Clematis gouriana	—	—	—	0.30	20	1.50	—	—	—	—	—	—
Clerondendron viscosum	0.80	45	1.70	—	—	—	0.12	50	2.40	—	—	—
Coffea bengalensis	—	—	—	—	—	—	0.45	25	1.80	—	—	—
Desmodium pulchellum	0.80	15	5 30	—	—	—	—	—	—	1 20	50	2.40
Dioscorea triphylla	0.22	10	2.50	—	—	—	—	—	—	—	—	—
Jasminum multiflorum	—	—	—	1.00	40	2.50	0.20	15	1.30	—	—	—
Lantana camara	0.10	5	2.00	—	—	—	—	—	—	—	—	—
Litsea glutinosa	—	—	—	0.30	20	1.50	—	—	—	—	—	—
Mallotus philippensis	0.65	35	1.80	—	—	—	—	—	—	—	—	—
Melia ezedarach	0.10	10	1.00	—	—	—	—	—	—	—	—	—
Murraya koenigii	1.50	60	1.75	0.40	30	1.30	0.75	35	2.10	—	—	—
Oplisimenus compositus	19.30	100	19.30	8.40	70	10.50	1.20	30	4.00	3.10	50	6.10
Oxalis acetosella	—	—	—	—	—	—	—	—	—	4.50	60	7.50
Shorea robusta	—	—	—	—	—	—	0.45	25	1.80	—	—	—
Solanum nigrum	—	—	—	0.10	20	1.00	—	—	—	—	—	—
Urena lobata	0.55	5	11 00	—	—	—	—	—	—	—	—	—
Vallaris solanacea	—	—	—	2.00	20	10.00	—	—	—	—	—	—
Total	47.32	—	—	35.40	—	—	69.82	—	—	18.10	—	—

A = Density (tree 100 m^{-2}); B = (%) Frequency; C = Abundance (tree 100 m^{-2}

Table 3

Quantitative analysis of tree cover in some plantations

Species Plantations	Density (tree 100 m^{-2})	Frequency (%) (F)	Abundance (tree 100m^{-2}) (A)	A/F	Mean basal area	Total basal cover (cm^2 100m^{-2})	Relative Frequency (%)	Relative Density (%)	Relative Dominance (%)	Importance Value Index (IVI)
Pinus roxburghii										
Cinnamomum camphora	2.55	75	3.40	0.045	117.31	299.31	19.23	23 29	5.64	48.16
Dalbergia sissoo	0.05	5	1.00	0.200	150.77	7.54	1.28	0.46	0.14	1.88
Flacourtia ramontchi	0.30	30	1.00	0.033	20.88	6.26	7.69	2.74	0.12	10.55
Mallotus philippensis	1.90	90	2.11	0.023	108.16	205.51	23.08	17.35	3.87	44.30
Michelia champaca	2.00	70	2.91	0.042	184.48	368.97	17.95	18.26	6.95	43.16
Pinus roxburghii	3.85	100	3.85	0.038	1441.89	4396.27	24 64	35.16	82.81	142 61
Syzygium cumini	0.25	30	1.25	0.042	97.89	24.47	7.13	2.74	0.46	10.33
Total	10.90	—	—	—	—	5308.33	—	—	—	—
Tectona grandis										
Cinnamomum camphora	0.10	10	1 00	0.100	81.45	8.14	4.54	1.59	0.28	6.41
Dalbergia sissoo	0.10	10	1.00	0.100	336.08	33.61	4 54	1.59	1.16	7.29
Flacourtia ramontchi	0.10	10	1.00	0.100	28.72	2.87	4.54	1.59	0.09	6.23
Litsea glutinosa	0.10	10	1.00	0.100	91.95	9.19	4 54	1.59	0.32	6.45
Mallotus philippensis	0.40	20	2.00	0.100	48.73	19.49	9.09	6.35	0.67	16.11
Syzygium cumini	1.40	70	2.00	0.028	35.36	99.44	27.27	22.22	4.82	54.31
Tectona grandis	4.10	100	4.10	0.041	652.38	2674.74	46.45	65.08	92.64	203.18
Total	6.30	—	—	—	—	2887.27	—	—	—	—
Shorea robusta	7.00	100	7.00	0.07	571.75	4002.21	100.00	100.00	100.00	300.00
Eucalyptus spp	17.00	100	17.00	0.17	65.11	1106.88	100.00	100.00	100.00	300.00

Table 4

Similarity Index (C) considering density of herbs, shrubs and trees for different plantations

Name of plantation	*P. roxburghii*	*T. grandis*	*S. robusta*	*Eucalyptus* spp.
P. roxburghii	100	36.60	26.64	11.36
T. grandis	—	100	33.07	10.68
S. robusta	—	—	100	2.41
Eucalyptus spp.	—	—	—	100

Table 5

Similarity Index (C) considering density of tree and shrub species and IVI value of trees species in brackets for different plantations.

Name of plantation	*P. roxburghii*	*T. grandis*	*S. robusta*	*Eucalyptus* spp.
P. roxburghii	100 (100)	31.21 (13.65)	30.80 (0)	3.03 (0)
T. grandis	—	100 (100)	37.48 (0)	2.15 (0)
S. robusta	—	—	100 (100)	0.31 (0)
Eucalyptus spp.	—	—	—	100 (100)

Table 6

Number of species, Diversity Index (H) and concentration of dominance (cd) in some plantations,

Name of plantation	On density basis						On I.V.I. basis		
	Includes herbs, shrubs & trees			Includes shrubs and trees			Includes trees only		
	A	B	C	A	B	C	A	B	C
P. roxburghii	36	3.6529	0 1521	26	3.6602	0.1271	7	2.1266	0 2967
T. grandis	26	3.3338	0.1131	17	3.2120	0.1544	7	1.5377	0.4591
S robusta	25	3.6325	0.1047	19	3.2944	0.1302	1	0	1
Eucalyptus spp.	7	0.0169	0 3180	2	0 9157	0.5578	1	0	1

A= No. of species; B= Diversity index (H); C= Concentration of dominance (cd)

provides meger compe'ition for invader hardwood species with planted one during germination and stabilization of their seedling and sapling. It may be one of the cause of more diversity of tree species in those two plantations.

The values of total basal cover (TBC) and density in several tropical forests ranged from 1073 to 3062 cm^2 100^{-2} and from 5.5 to 11.70 trees 100 m^{-2} respectively, while for temperate forests, the same ranged from 1560 to 6045 cm2 100 m^{-2} and from 3.2 to 20.80 tree 100 m^{-2} (Dabel and Day, 1977; Saxena and Singh, 1982; Ralhan *et al*, 1982). In the present study, TBC values are well within the reported range for temperate forests but exceeded those of the tropical forests for sal and pine, however, the values of density are in the range reported for tropical forests (Table 3).

The distribution pa'terns of different tree species were contagious almost in all the plantations except, pine where it was random for most of the species and rarity of regular distribution. The con'agious (clumped) distribu ion, is more characteristic pattern of nature (Odum, 1971). The random distribution, which is indicative of uniform environment was reported for some natural forests of temperate zone (Saxena and Singh, 1982; Singhal *et al.*, 1986).

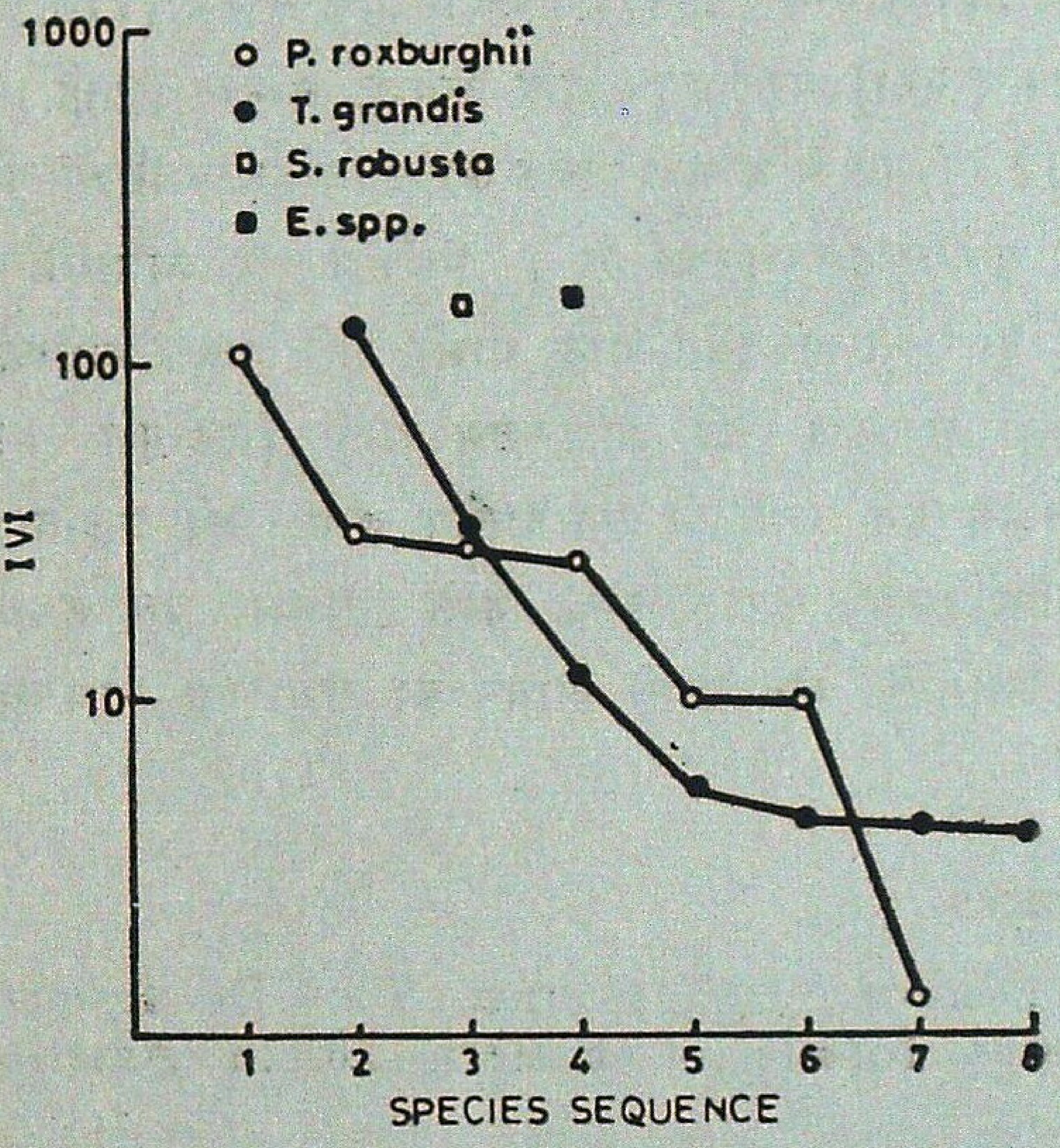
All the plantations of the present study have shown a remarkable degree of dissimilarity of species in composition and structure inspite of uniform macroenvironment. Hence it seems that not only macroenvironment, but the nature of species planted may change the microclimate, which inturn may affects the species diversity. The herbs and shrubs are more sensitive to subtle environmental differences than trees, which is clear from Tables 4 & 5.

The diversity index is generally higher for tropical forests (5.06 and 5.40 for young and old stand, respectively, Knight, 1975), while it is reported to lie between 1.16-3.40 for temperate forests (Braun, 1950; Monk, 1967: Risser and Rice, 1971). Though the plantations of present study are located in subtropical zone, the values of diversity index are markedly lower than those reported for tropical forests. These lower values may be due to the effect of homogeneous nature of plantations, especially of those, planted as monoculture.

The values of concentration of dominance for temperate vegetation lie within the range of 0.10-0.99 (Whittaker and Niering, 1965; Rissar and Rice, 1971), while for tropical forests, the average value is 0.06 (Knight, 1975). Thus the values of concentration of dominance (cd) also fall in the range of values reported for temperate forests and are considerably higher than those of tropical forests (Table 6). The higher values of concentration of dominance could be due to lower rate of evolution and diversification of communities in plantation ecosystem. The same has also been reported for temperate vegetation (Fischer, 1960; Connel and Orias, 1964; Simpson, 1964).

The IVI values of tree species have been plotted against the species sequence as dominance diversity curve for the studied plantations to interpret the community organization in terms of resource share and niche space (Fig. 1). The curve for the

Fig. 1



Dominance diversity curve

plantations of teak and pine follows the lognormal series, which confirm the niche-premption hypothesis (Whittaker, 1975). Moreover, sal plantations indicate single species dominance, which tendency is also pronounced for eucalypts.

It can be concluded from the preceding discussion that species diversity is being regulated by long term factors like community stability and evolutionary time as heterogeneity of both micro and macro-environment affects the diversification among different communities. Hence, in plantation forestry, it appears that different silvicultural operations like thinning, burning, weeding, etc. may create a possible route for the invasion of new species even during the premature age of the stands.

SUMMARY

The present study deals with the comparative vegetation analysis of the four plantations of sal, teak, pine and eucalypts at New Forest, Dehra Dun. The higher density values and species richness in the plantations of pine, sal and teak were due to the stand maturity. The total basal cover (cm^2 100 m^{-2}) followed the order; Pine (5308.33) > sal (4002.21) > teak (2887.27) > eucalypts (1106.88), whereas IVI was the highest for eucalypts and sal (300) followed by teak (203.18) and pine (142.61) in their respective plantations. Comparatively, more diversity was observed for pine, while minimum for euculypts stand on both density and IVI basis. The distribution pattern of different tree species was contagious in all the plantations exept pine, where it was random for most of the species. The highest values of concentration of dominance (on IVI basis) observed for sal and eucalypts, are attributed to the monospecific nature of their stands. In conclusion, it seems that different silvicultural operations like thinning burning, weeding, etc. my create a possible route for the invasion of new species even during the premature age of the plantation.

कतिपय रोपवन परिस्थिति संहतियों की वनस्पति का तुलनात्मक विश्लेषण

पी०के० पांडे, ए०पी०एस० बिष्ट व एस०सी० शर्मा

सारांश

इस अध्ययन में न्यूफॉरेस्ट, देहरादून में लगे हुए साल, सागौन, चीड़ और यूकेलिप्टस इन चार रोपवनों की वनस्पति के तुलनात्मक विश्लेषण को लिया गया है। चीड़, साल और सागौन वनों की अधिक सघनता

अर्हा और पादक जाति सम्पन्नता इन रोपवनों की प्रौढता के कारण है। इनका कुल आधारिक क्षेत्रफल (सेमी^{2} 100 मी$^{-2}$) इस अनुक्रम में है : चीड़ (5308.33) साल (4002.21) सागौन (2887.27) और यूकेलिप्टस (116.88) किन्तु एकीकृत अर्हा निर्देशांक युकेलिप्टस और साल का अधिक (300) था जिसके बाद क्रमश: सागौन (203.18) और चीड़ (142.61) रोपवन आते हैं। तुलनात्मक दृष्टि से चीड़ रोपवन में अधिक पादक जाति विविधता मिली और सबसे कम सघनता और एकीकृत अर्हा निर्देशांक आधार पर युकेलिप्टस रोपवन में। विभिन्न वृक्ष जातियों की वितरण सज्जा चीड़ को छोड़ अन्य सभी रोपवनों म एक दूसरे से संक्रमित होने वाली रही, वहाँ अधिकाँश पादक जातियों के लिए सममभावित थी। प्राधिरोहिता सकेन्द्रण की अधिकतम अर्हा (एकीकृत अर्हा निर्देशांक आधार पर) साल और युकेलिप्टस की रही जिसे इन वनों की एकजातीय होने की प्रकृति से जोड़ा जा सकता है। निष्कर्षत: ऐसा प्रतीत होता है कि इनमें कराए जाने वाले विभिन्न वन संवर्धन कार्य जैसे विरलन, दाहन, निराई आदि इनमें नई पादक जातियाँ जबरदस्ती आने का संभावित मार्ग बना सकते है चाहे तब तक रोपवन प्रौढतापूर्व अवस्था मे ही हो।

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SOIL VEGETATION RELATIONSHIP STUDIES IN SOME SELECTED TREE SPECIES OF MUDUMALAI FOREST DIVISION

JASBIR SINGH, G.N. GUPTA* AND K G. PRASAD**

Forest Soil Vegetation Survey, Southern Region, Coimbatore (Tamil Nadu)

Introduction

In a forest ecosystem, vegetation, climate and soil exist in intimate dynamic relationship, however a complex one. Growth and distribution of different tree species is the resultant effect of interaction of climate and soil. Of the various factors of climate and soil, the one in minimum, controls the growth of plants (Liebig, 1840). Soil factors have the overriding importance for they could be manupulated to produce higher yields. The studies on growth and distribution of various tree species in natural conditions in relation to clima'ic, soil and topograhic factors are few (Singh *et al.*, 1985, Gupta *et al.*, 1986a) and there is need to identify various climatic and soil fators influencing the growth of different forestry crops in their natural occurrences.

Present investigation attempts to find out the growth of *Anogeissus latifolia*, *Terminalia tomentosa* and *Tectona grandis* in relation to climatic, soil and topographic factors in Mudumalai Forest Division of Tamil Nadu.

Materials and Methods

The present study was carried out in Mudumalai wildlife sanctuary which is situated between 11°32′ and 11°43′N latitude and 76° 22′ and 76 °45′ E longitude on the southern slopes of Nilgiris. Terrain is undulating with slopes varying from 2° to 23°. In the study area elevation varies from 650 m to 1250 m, annual rainfall from 950 mm to 1750 mm and temperature from 24°C to 25°C. The area is typified by both south-west and north-east monsoon. The major portion of rainfall is received from north-east monsoon (October to December). The rocks are typical archean biotite and hornblende gneiss.

Data on density and girth of *Anogeissus latifolia*, *Terminalia tomentosa* and *Tectona grandis* were collected during soil and vegetation survey of the division. A total of 53 quadrats were studied at an interval of 1 to 2 km (Sharma *et al.*, 1983 and 1986). Within each quadrat soil profile was exposed and morphological characteristics were studied as per FAO (1977). Soil samples from each horizon were collected and analysed for their physical and chemical properties following standard methods (Jackson, 1967). Slope and elevation of each site were recorded. All the quadrats were grouped into three groups as low,

Presently at : * Forest Research Institute Centre, Jodhpur (Rajasthan). ** Forest Soil Vegetation Survey, Forest Research Institute, Dehra Dun (U.P.).

medium and high based on girth (circumferences) and density/ha of each species. For grouping, mean and standard deviation (SD) of density and girth were calculated. Values less than mean - ½ SD were taken as group 'low', values mean - ½ SD to mean +½ SD as 'medium' and values more than mean +½ SD as 'high'. Weighted mean of each genetic horizon for four soil depths (0–18 cm, 18–50 cm, 50–100 cm and 100–200 cm) was calculated for selected physico-chemical properties for ease of comparison. Data so obtained were subjected to 't-test'.

Results and Discussion

Anogeissus latifolia: Higher density of *A. latifolia* in low rainfall areas indicates its dominance as compared to other species in a dry zone (Table 1). However, tree growth (girth) improved with increasing rainfall. Thus the species, though could be planted on dry lands, has a potential to produce higher biomass with the management of soil moisture. Though, higher density was recorded on shallow soils, deeper solum depth supported good growth of trees. Likewise, thickness of 'A' horizon direc ly affected the plant growth; though density showed no significant relationship.

Variation in soil pH did not effected plant density. However, slightly acidic soil reaction (pH 6.0 to 6.5) was favourable for better growth of *A. latifolia* (Table 2). Better growth of plants was recorded on the soil having higher clay content in surface and subsurface layers. Sand content exhibited an inverse relationship. The plant density, however, was not significantly influenced by soil texture. Exchangeable calcium and magnesium in soil profile did not vary at different sites having varying growth. However, in general high calcium and magnesium contents were recorded at sites of high density of *A. latifolia* which

Table 1

Girth and denisty of A. latifolia in relation to climate and soil factors.

Factors	Girth (cm)			Density (Plants/ha)		
	Groups			Groups		
	Low (<75 cm)	Medium (75-114 cm)	High (>115 cm)	Low (<75/ha)	Medium (75-150/ha)	High (>150/ha)
Solum depth (cm)	75.4[a] ±35.3	81.5[b] ±41.1	108.9[ab] ±40.3	88.8 ±43.2	104.7[b] ±38.7	70.3[b] ±34.2
Rainfall (mm)	1199.5 ±288.08	1125.0[b] ±150.3	1342.9[b] ±169.7	1250.0 ±256.7	1227.1 ±189.3	1156.3 ±167.3
Depth of 'A' horizon	28.8 ±38.3	18.1[b] ±9.4	36.1[b] ±12.9	24.3 ±15.9	30.0 ±15.5	31.1 ±40.6

Values with similar letters in rows are significantly different using 't-test'.

possibly was associated with low rainfall. Higher CEC of npper 50 cm soil layer was recorded at sites having good growth and density. Sites having good growth and density of *A. latifolia* were poor in organic carbon.

Table 2

Girth and density of A. latifolia in relation to physical and chemical properties of soils

Soil properties	Girth (cm)		Density/ha		
	Groups		Groups		
	Low (<75 cm)	High (75-114 cm)	Low (<75/ha)	Medium (75-150/ha)	High (>150/ha)
			0 - 18 cm		
pH	7.0[a] ± 0.7	6.5[a] ± 4.7	6.6 ± 0.6	6.9 ± 0.7	7.1 ± 0.8
Sand (%)	50.0[a] * 6.6	44.1[a] * 7.7	48.0 * 6.8	46 3 *10.5	42.8 * 8 6
Clay (%)	28.6[a] * 4.5	32.9[a] * 6.9	29.4 * 5.6	31.5 * 9.2	31.2 * 7.6
Ca^{++} (meq%)	24.5 * 12.5	21.3 * 9.9	17.5[ac] *10.0	24.1[a] *13.4	29.4[ac]* 15.9
Mg^{++} (meq%)	4.4 * 4.4	3.4 * 3.1	3.2[a] * 2.0	4.9[a] * 6.4	5.3[a] * 3.3
CEC (meq%)	20.5[a] * 8.2	27.7[a] * 10.0	22.3[ac] * 9.7	24.3[a] *10.7	30.1[ac] * 8.3
			18-50 cm		
pH	7.1[a] * 0.7	6.5[a] * 0.4	6.6 * 0.6	6.9 * 0.8	6.0 * 2.5
Sand (%)	45.9 * 7.2	42.4 * 9.2	47.3[a] * 7.0	42.5 *12.1	39.7 * 8.6
Clay (%)	31.2 * 6.9	34.7 * 9.5	30.1[a] * 6.7	36.2 *12.1	31.7 * 6.9
Ca^{++} (meq%)	24.0 * 13.8	16.7 * 9.4	16.3[a] *11.0	23.0 *14.7	28.0[a] * 18.1
Mg^{++} (meq%)	3.1 * 1.9	3.5 * 2.9	3.0[a] * 2.0	3.0[a] * 3.1	5.3[a] * 3.2
CEC (meq%)	19.7[a] * 7.7	27.2[a] * 9.3	21.6[abc]* 9.1	22.7[b] * 9.1	28.9[ac]* 8.4
Org. carbon (%)	1.3[a] * 0.5	1.7[a] * 0.5	1.5 * 0.5	1.5 * 0.3	1.3 * 0.7
			50-100 cm		
pH	6.6[a] * 2.1	6.1[a] * 1.8	5.9 * 2.2	6.5 * 2.2	4.6 * 3.8
Sand (%)	38.6 * 19 5	38.6 * 18.5	40.9[a] *19.7	35.7 *17.6	21.0[a] * 24.6
Clay (%)	28 4[a] * 16.2	35.3[a] * 16.2	29.7[ac] *15.5	35.9[ab]*18.4	27.2[abc]* 20.5
Ca^{++} (meq%)	19.2[a] * 16.7	10.6[a] * 7.8	11 7[ab] *11.5	20.9[ab]*16.9	10.5 * 12.1
CEC (meq%)	15.9 * 0.0	21.0 * 11.3	16.4[a] * 9.5	19.4[a] *11.0	10.1 * 13.4

Values with similar letters in rows are significantly different using 't-test'.

* denotes ±

Table 3

Girth and density of T. tomentosa in relation to climate and soil factors.

Factors	Girth (cm)		Density/ha	
	Groups		Groups	
	Low (<100 cm)	High (>151 cm)	Low (<25/ha)	High (>51/ha)
Solum depth (cm)	89.7 ±51.5	124.8 ±38.9	100.1 ±43.6	120.3 ±37.8
Slope (%)	8.4 ±4.0	8.2 ±3.9	7.4[a] ±4.3	10.2[a] ±2.9
Rainfall (mm)	1286.1[a] ±157.7	1472.9[a] ±198.1	1341.7[a] ±160.0	1525.0[a] ±194.7

Values with similar letters in rows are significantly different using 't-test'.

Terminalia tomentosa : Higher the rainfall (more than a mean of 1472 mm) better was the growth of *T. tomentosa* (Table 3). Higher plant density was recorded in regions having more than 1525 mm rainfall. A soil depth of more than 120 cm supported dense stands of thick trees. Denser stands of this species were found on slopy lands (10.2% ± 2.9).

Lower soil pH (6 16 to 6.21) of upper 50 cm layer was recorded on sites having higher density (Table 4). This appears to be in consonance with relatively higher rainfall of these sites.

Good growth and density of *T. tomentosa* was associated with lower P_2O_5, K_2O and exchangeable Mg contents of upper 50 cm soil layer. Deeper layers, in general, did not vary significantly in these contents. The poor fertility status of these sites might be attributed to relatively higher rainfall and slope resulting in washing away of soluble nutrients in runoff. The relatively lower available nutrient content in the upper 50 cm, further indicates that *Terminalia tomentosa* may be a surface feeder. Organic carbon content did not vary significantly at different sites.

Tectona grandis : Density of teak did not show significant variation due to rainfall in the study area (Table 5). The teak growth was better in relatively high rainfall areas of the division. An average of 1388 mm rainfall was found at the sites having good girth of teak. Girth and density of teak remained unaffected due to soil depth which varied from 92 to 123 cm (mean) Thickness of 'A' horizon, in general, was higher at sites having good growth and density of teak. Probably teak stands have a positive effect on soil conservation and checks the erosion of surface soil.

Table 4

Girth and density of T. tomentosa in relation to physical and chemical properties of soils.

Soil properties	Girth (cm)		Density/ha	
	Groups		Groups	
	Low (<100 cm)	High (>151 cm)	Low (<25/ha)	High (>51/ha)
		0–18 cm		
pH	6.5 ± 0.4	6.3 ± 0.5	6.5[a] ± 0.3	6.2[a] ± 0.4
Mg^{++}	6.0 * 6.9	4.0 * 4.1	5.3 * 5.5	4.7 * 5.9
P_2O_5 (kg/ha)	101.6[a] * 52·7	94.4[a] * 75.3	78.8 * 76.9	74.5 * 5.5
K_2O (kg/ha)	881.0 *651.5	693.9 *418.1	929.9 * 800.9	603.9 * 244.4
Org. carbon (%)	2.3 * 0.9	2.6 * 0.7	2 7 * 6 9	2.5 * 5.0
		18–50 cm		
pH	6.4 * 0.4	6 3 * 0 6	6.4[a] * 0 3	6.2[a] * 0.5
Mg^{++} (meq %)	3.6 * 2.9	3.3 * 3.1	5.0[a] * 3.4	2.4[a] * 2.9
P_2O_5 (kg/ha)	71.9[a] * 33.9	61.3[a] *103.2	78.9 *115 9	40.9 * 36.6
K_2O (kg/ha)	563.1[a] *288.8	334.2[a] *144.0	510.1[a] *333.6	333.5[a] * 114.3
Org. carbon (%)	1.4 * 0.3	1.5 * 0.6	1.6 * 0.3	1.4 * 0.5
		50–100 cm		
pH	6.0 * 12.9	6.3 * 10.6	5 8 * 12.2	6.1 * 10.5
Mg^{++} (meq %)	2.5 * 12.0	3.5 * 2.6	3.9 * 2.5	2.5 * 2.2
P_2O_5 (kg/ha)	44.8[a] * 31.2	46.8[a] * 39.5	32.3 * 24.2	42.1 * 44.3
K_2O (kg/ha)	370 8[a] *273.6	297.4[a] *242.4	254.7 *219.8	263.7 * 219.2

Values with similar letters in rows are significantly different using 't-test'.
* denotes ±

Most of the physical and chemical properties of soils of the study area did not exhibit marked association with growth and density of teak (Table 6). A higher calcium content of surface layer was significantly related to good growth of teak. Higher organic carbon and silt contents in 18 to 50 cm layer were recorded at sites of good growth and density.

Conclusion

Soil vegetation relationship studies were conducted with particular reference to *A. latifolia*, a fuelwood species, and *T. tomentosa* and *T. grandis*, the important timber plants. It was found that density of *A. latifolia* and *T. grandis* was not affected by variation in rainfall within study area, however, a better growth was noted at high rainfall sites. Thus, the species may be grown in low rainfall areas with suitable moisture conservation practices for higher biomass. *T. tomentosa* on the other hand,

Table 5

Girth and density of Tectona grandis in relation to climate and soil factors

Factors	Girth (cm) Groups		Density/h Groups	
	Low (< 100 cm)	High (> 176 cm)	Law (<50/ha)	High (> 101/ha)
Solum depth (cm)	93.73 ±50.64	107.19 ±48.26	123.50 ±48.79	92.25 ±44.91
Rainfall (mm)	1188 64[a] ±160.99	1387.50[a] ±210.16	1303.13 ±318.04	1265.63 ±126.73
Depth of 'A' horizon (cm)	22.55 ±19.42	28 31 ±13.99	17.75 ±16.46	33.38 ±40.79

Values with similar letters in rows are significantly different using 't test'.

requires relatively higher rainfall (> 1525 mm) for its better stock and growth. Further the performance of former two species is not adversely affected by shallow depth of soil, and thereby could be suitable for truncated soils. Growth and density of *T. tomentosa* was better on sites which were poor in P_2O_5, K_2O and Mg content which probably was due to high rainfall and slopy topography of these areas. *T. tomentosa*, preferred deep soils (<20 cm of solum depth). Occurrence of this species on slopy lands testified its suitability on well drained soils.

Physical and chemical properties did not exhibit significant relationship with density and growth of various tree species. Nontheless, higher calcium content was associated with sites of good growth and density of teak. Higher calcium and magnesium contents were recorded at sites of densely populated *A. latifolia*. The results corborates the findings of Yadav and Sharma (1968) who reported that teak has relatively shallow root system and could meet its water and nutrient requirement from smaller soil masses.

Table 6

Girth and density of T. grandis in relation to physical and chemical properties.

Soil properties	Girth (cm)		Density/ha	
	Groups		Groups	
	Low (< 100 cm)	High (> 176 cm)	Low (< 50/ha)	High (> 101/ha)
1	2	3	4	5
		0 - 18 cm		
pH	6.7 ± 0.4	6.5 ± 0.6	6.4 ± 0.8	6.8 ± 0.6
Sand (%)	47.0 * 9.5	45.3 * 7.0	50.1[a] * 10.5	44.5[a] * 0.9
Silt (%)	21.1 * 5.7	23.2 * 7.4	21.0 * 7.0	22.9 * 8.2
Clay (%)	31.8 * 6.7	31.5 * 6.4	28.9 * 7.2	32.5 * 9.8
Ca^{++} (meq%)	16.3[a] * 11.7	29.6[a] * 43.1	27.8 * 61.4	22.9 * 13.6
Mg^{++} (meq%)	7.5 * 7.8	5.0 * 3.5	7.8 * 7.3	7.8 * 5.7
CEC (meq%)	24.5 * 10.7	27.3 * 11.0	23.1 * 11.0	29.3 * 7.7
P_2O_5 (kg/ha)	91.4 * 46.8	99.2 * 152.8	145.9 *212.1	111.2 * 78.1
K_2O (kg/ha)	818.9 *646.8	706.8 * 557.3	707.5 *440.5	1097.9 *725.7
Org. carbon (%)	2.2 * 0.8	2.5 * 0.7	2.2 * 0.6	2.3 * 1.2
		18 - 50 cm		
pH	6.7 * 0.6	6.4 * 0.5	6.5 * 0.9	6.8 * 0.7
Sand (%)	45.7 * 12.0	43.0 * 9.7	48.2 * 14.3	42.6 * 11.6
Silt (%)	19.3 * 5.4	21.6 * 8.1	19.1[a] * 4.3	24.8[a] * 9.3
Clay (%)	34.9 * 10.4	35.2 * 9.1	32.8 * 14.2	31.8 * 6.4
Ca^{++} (meq%)	14.6 * 12.1	15.4 * 7.2	14.2 * 11.8	19.3 * 14.8
Mg^{++} (meq%)	4.4 * 3.7	5.5 * 5.8	6.1 * 8.1	6.5 * 4.0
CEC (meq%)	22.8 * 10.5	24.8 * 9.7	21.1 * 9.4	26.2 * 6.9
P_2O_5 (kg/ha)	79.0 * 60.4	47.8 * 62.0	91.8 *103.4	88.5 * 121.2
K_2O (kg/ha)	475.7 *305.0	398.1 *2213.0	413.4[a] *235.2	716.3[a] * 460.2
Org. carbon (%)	1.4[a] * 0.4	1.7[a] * 0.5	1.2[a] * 0.5	1.4[a] * 0.5

(Contd...)

1	2	3	4	5
		50 - 100 cm		
pH	5.8 * 3.0	6.0 * 1.7	5.7 * 2.4	5.7 * 3.6
Sand (%)	33.4 * 21.4	37.1 * 16.7	36.8 * 19.4	32.7 * 23.0
Silt (%)	15.6 * 8.8	19.1 * 8.2	17.0 * 9.4	17.1 * 11.4
Clay (%)	32.8 * 20.2	37.3 * 15.1	33.9 * 20.9	25.1 * 18.3
Ca^{++} (meq%)	12.3 * 14.3	11.3 * 7.5	14.2 * 14.9	13.8 * 13.8
Mg^{++} (meq%)	3.1 * 2.3	6.0 * 6.2	6.1 * 8.8	7.3 * 9.5
CEC (meq%)	15.9 * 11.5	21.0 * 11.9	19.1 * 11.3	17.8 * 12.2
P_2O_5 (kg/ha)	41.2 * 22.8	34.0 * 47.1	47.9 *340.3	34.0 * 40.6
K_2O (kg/ha)	345 4 *258.1	263.0 * 217.2	340.3 *273.7	248.5 *268.1
Org. carbon (%)	0.7 * 0.4	0.8 * 0.4	0.6 * 0.3	0.6 * 0.5

Values with similar letters in rows are significantly different using 't-test'.

* denotes ±

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SUMMARY

Present paper envisages information on the influence of climate, soil and topographic factors for the growth and distribution of three important tree species namely *Anogeissus latifolia*, *Terminalia tomentosa* and *Tectona grandis* in Mudumalai Forest Division of Tamil Nadu. *T. tomentosa* was found suitable in regions having > 1525 mm of annual rainfall, whereas *A. latifolia* and *T. grandis* performed well in the relatively lesser rainfall areas as well. *T. tomentosa* prefers very deep soils (> 120 cm) whereas good growth and density of *T. grandis* and *A. latifolia* were recorded on moderately deep soils. Density and growth of *T. grandis* was higher on medium textured soils whereas the density of *A. latifolia* was not affected by coarse textured soils. Higher growth and density of *T. tomentosa* was associated with poor P_2O_5, K_2O and Mg contents of the soil *A. latifolia* and *T. grandis* were found on soil rich in Ca and Mg. Soils rich in organic carbon and CEC occurred under better growth and density of teak.

मुडुमलाई वन मण्डल की कतिपय चुनी हुई वृक्ष जातियों में मृदा और वन सम्बन्धों का अध्ययन

जसबीर सिंह, जी०एन० गुप्त व के०जी० प्रसाद

सारांश

प्रस्तुत अभिपत्र में तमिलनाडु के मुडुमलाई वन मण्डल की तीन महत्वपूर्ण वृक्ष जातियों अर्थात एनोगाइसिस लैटिफोलिया, टर्मिनेलिया टोमेनटोसा और टैक्टोना ग्रांडिस की वृद्धि और वितरण पर जलवायु,

मृदा और स्थलाकृति कारकों के प्रभाव की जानकारी उपस्थित की गई है । ट० टोमेनटोसा उन क्षेत्रों में उपयुक्त रहता है जहां वर्ष भर में 1525 मिमी० वर्षा होती है, ए० लैटिफोलिया और टं ग्रॉडिस उन क्षेत्रों में भलीभाँति फले-फूले जहां अपेक्षतया कम वर्षा होती है । ट० टोमेनटोसा को अधिक गहरी मृदाए (120 सेमी०) पसन्द है परन्तु टै० ग्रॉडिस और ए० लैटिफोलिया की अच्छी बढ़वार और सघनता मध्यम गहरी मृदाओं में देखी गई है । टै० ग्रॉडिस की सघनता और वृद्धि मध्यम वयन वाली मृदाओं में अधिक निकली किन्तु ए० लैटफोलिया की सघनता स्थूल वयन मृदाओं से अप्रभावित रही । ट० टोमेनटोसा की अधिक बढ़वार और सघनता मृदा में फास्फोरस, पोटाश, मैग्नीशियम तत्व कम रहने से सम्बन्धित है । ए० लैटिफोलिया, टै० ग्रॉडिस कैलिशियम और मैग्नीशियम सम्पन्न मदाओं में मिले जैव कार्बन सम्पन्न और केटायन विनिमय क्षमता वाली मृदाए सागौन की वृद्धि और सघनता के लिए उपयुक्त रही ।

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NEW RECORDS OF PREDATORS OF THE MELIACEAE SHOOT BORER *HYPSIPYLA ROBUSTA* MOORE (LEPIDOPTERA : PYRALIDAE)

PRATAP SINGH AND RAM MOHAN MISRA

Forest Entomology Branch, Directorate of Biological Research,
Forest Research Institute, Dehra Dun (India)

Introduction

The Meliaceae shoot borer *Hypsipyla robusta* Moore (Lepidoptera : Pyralidae) is an important pest of trees belonging to family Meliaceae in sub-tropical and tropical forests of Africa, Australia, Burma, Ceylon, India and Taiwan. Attempts to raise cedrela and mahogany plantations have not succeeded in India so far. In India Beeson (1919) and Rao and Bennett (1969) have reported large number of parasities parasitising the shoot borer but as regards predators only larvae and adult beetles of *Idgia flavibuccis* Bourg, *I. melanura* Kollar & Redt (Melyridae) and *Opilo discodirus* Corporal, (Cleridae) were the only predators observed predating upon *H. robusta* larvae. In Java, Kalshoven (1926) have reported a predaceous wasp *Icana* sp. a myriapod, ants and shrews predating upon *H. robusta* larvae. A survey for the predators of *H. robusta* from 1973 to 1978 of Dehra Dun Valley revealed five insect predators viz. one reduvid, one formicid, two carabids, one mentid and common myna and five striped squirrel were recorded predating upon *H. robusta* for the first time. These predators take an appreciable toll of shoot borer larvae and pupae. In the absence of a satisfactory chemical or silvicultural method to control *H. robusta*, these natural enemies can also be used for its biological control. Therefore, it was considered worthwhile to study the potentialities of these natural enemies. A brief account of each predator and its potentialities is given in this paper.

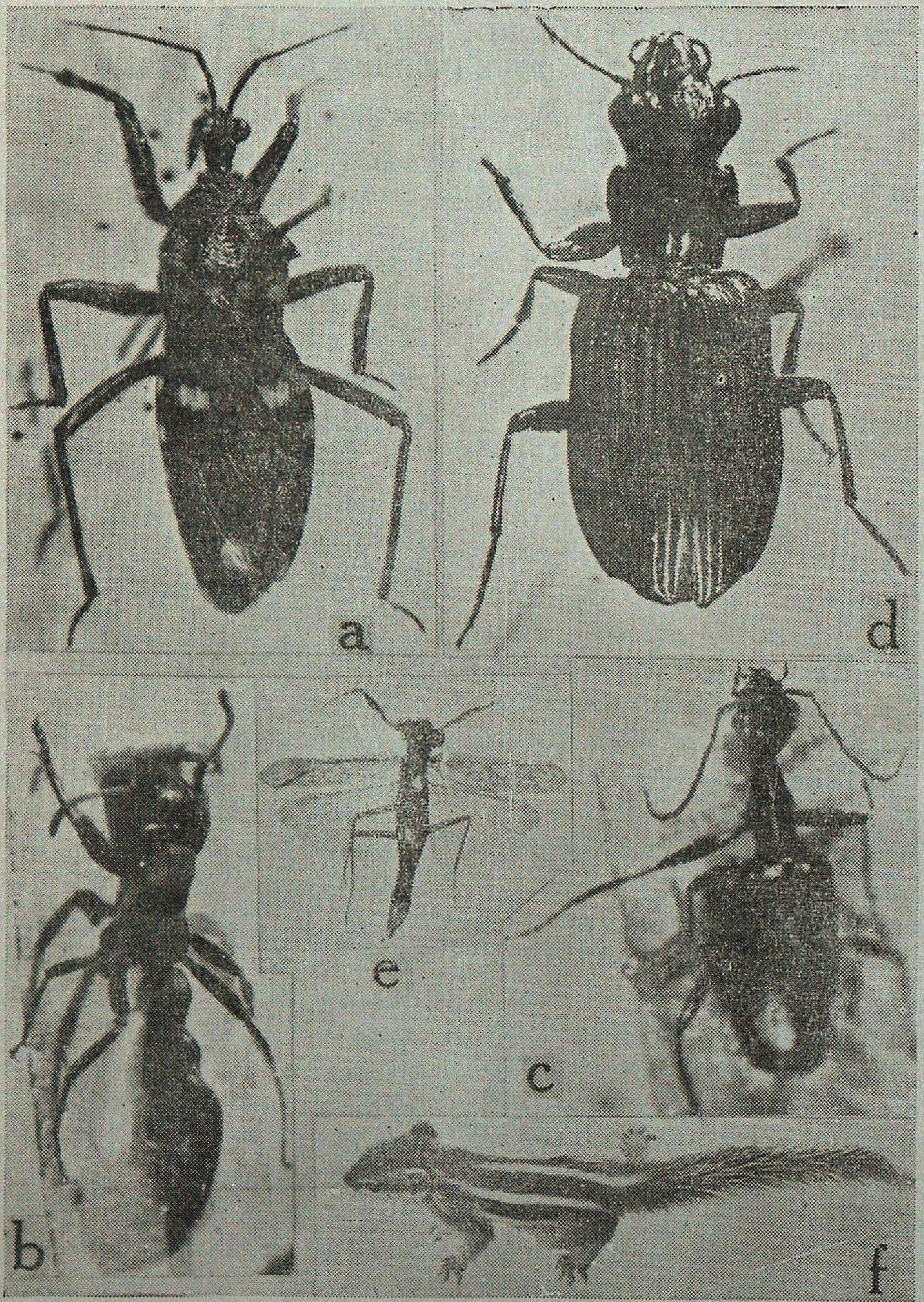
Materials and Mathods

Surveys and collections were carried out throughout the year and continued for four years. The behaviour of insect predators was observed in the field. Insect predators were also reared in the laboratory in glass chimney cages and fed on *Hypsipyla robusta* larvae.

Invertebrata : Insecta

Hemiptera : *Acanthaspis rama* Dist. (Reduviidae) (Plate 1, fig. a). Both adults and nymphs of the assassin bug were recorded predating upon fourth instar larvae of *H. robusta* in the field. The predator kept waiting under the flakes of bark on toon trees and as the last instar larvae descend down to go underneath the bark or in crevices for pupation, they were preyed upon by the assassin bug *A. rama*, took a heavy toll of the fruit boring generations in May-June. The assassin bug inserts its probosis in the body of *H. robusta* larvae and sucks the liquid till the larva shrunk and died. Four *H. robusta* larvae of second instar introduced in the cage were eaten in 24 hours. It consumed forty larvae during a span of ten days in the laboratory. The predators

Plate 1



Predators of Meliaceae shoot boıer—*Hypsipyla robusta* Moore (a) *Acanthaspis rama* Dist., (b) *Tetraponera rufonigra* Jerd., (c) *Odacantha bimaculata* Redt., (d) *Catascopus facialis* Weid., (e) *Amorphoscelis indica* Giglio Tos., (f) *Funambulus pcn ıanti* Wr.

were common on shoot borer attacked fruiting trees. Percentage of predation by this assassin bug was recorded from 15–20% in the month of May–June. The predator is polyphagous in habit and its prey includes other lepidopterous larvae also.

Adult, is 22–24 mm long is blackish brown in colour posterior lobe of pronotum is with two rounded basal spots, corium with small basal spots and a larger rounded subapical spot. There are spots above and beneath the abdominal margin (connexivum) and apices of femora. Two broad annulations on tibiae, and the tarsi are brownish yellow. The pronotum has its anterior lobe moderately sculptured, posterior lobe transversely rugulose with the posterior angles dentately produced and their apices slightly recurved. The scutellar spine, obliquely ascendant (Distant, 1903). They are warningly coloured and protect themself by their odour and probably by the stout spines on the thorax. The bug has also been recorded from Behrampur, Pusa (Bihar) and Sikkim.

Hymenoptera : *Tetraponera rufonigra* Jerd. (Syn. *Sima rufonigra* Jerd.) (Formicidae) (Plate 1, fig. b). The sepoy ant, *Tetraponera rufonigra* Jerd. was recorded as a new predator of second, third and fourth instar fruit boring larvae of *H. robusta* from New Forest. The sepoy ant used its sting to paralyse the larva and then holding the prey by its first pair of legs, it tore away with mandibles a portion of the body tissue. While feeding it vibrated its antennae vigorously. Only part of the larval body (10% to 50%) was eaten and the rest discarded. Two larvae were killed and partly eaten per day by an individual. In field sometimes about five hundred dead and partly larvae of *H. robusta* were collected from the base of a single toon tree with large number of sepoy ants. Apparantely the dead and halfeaten larvae were discarded by the sepoy ants after a partial meal. 30 to 40 per cent predation of *H. robusta* larvae was observed during May. *Tetraponera* appears to be exerting appreciable natural control on the shoot borer. Once it was observed that when *T. rufonigra* bit a *H. robusta* larva, a colourless liquid came out from the body of the larva and the larva wriggled violently till it died. After sometime of the bite a colourless liquid came out of the mouth of the ant, the ant also died due to some unknown reason. The sepoy ant consumed two larvae per day in the laboratory. Twenty *H. robusta* larvae were eaten by the ant during its life of 10 days in the cage.

Adult, is 11–13 mm long has a red thorax and black head and body. Head, the second joint of the pedicel and abdomen are black, the mandibles, antennae, thorax and first joint of the pedicel are more or less red, varying from light orange red or orange yellowish to deep dark brick, red mandibles clypeus and antennae are yellowish red. Pilosity and pubescence are sparse, the former consisting of a few scattered pale hairs, the latter absent, but when present very thin short and silky, giving the thorax and abdomen especially a whitish pubescent appearance. Head, legs and joint of the pedicel and the abdomen are shinning. Thorax is elongate, the pronotum is broad with its anterior lateral angles dentate and a medial small longitudinal tubercle at its posterior margin, Legs are moderately long and stout. Pedicel is elongate. Abdomen is somewhat small, oval, acute at apex, with an exserted sting. Female

very closely resembles the male but is slightly larger and more massive.

This species is the most virulent of ants, its sting being most painful to humans, it bites sometimes raising considerable inflamation. The sepoy ant is widely distributed in India.

Coleoptera : *Odacantha bimaculata* Redt. (Syn. *Casnonia bimaculata* Redt.) (Carabidae) (Plate 1, fig. c), was recorded as a new predator of third instar shoot boring larvae of *H. robusta* from New Forest during August. Percentage predation was 2-3 per cent. Beetles kept searching for borer attacked fruits and shoots with their long neck probed and caught the larvae, inside the shoots and fruits. In one case two beetles were observed feeding on the same larva. The beetle consumed practically the whole larva. Two second instar larvae per day were eaten by *Odacantha*. 24 larvae were eaten up during its life span of 11 days in the cage.

Adult is a brownish black beetle about 14 mm long with head narrowed behind to condyliform neck. Prothorax is subcylinderical with more or less lateral borders. Head and thorax is brown and abdomen is black with 2 white spots. The species is widely distributed in India.

Catascopus facialis Weid (Carabidae) (Plate 1, fig. d) was recorded as a new predator of second, third and fourth instar shoot boring larvae of *H. robusta* from New Forest in May-June. The beetle consumed the entire larval body. Percentage of predation recorded was low 1 to 2%. These beetles are found under loose bark of toon. Three to four larvae per day were eaten by the carabid and thirty larvae were consumed by it during its life of 10 days in the cage.

Beetles are bright metallic blue in colour and 13-15 mm, in length. The disc of elytra is more or less blue. the base is often greenish. This carabid predator is widely distributed throughout the country.

Mantoidea : *Amorphoscelis indica* Giglio Tos (Mantidae) (Plate 1, fig. e). This mantid is 18-20 mm long is common on bark of trees including *Toona ciliata*. The species is dull grey in colour and matching with the colour of the bark of toon trees. Among its varied diet are included 2nd and 3rd instar larvae of *H. robusta*. 4-5% predation was recorded in May-June. In laboratory cage it fed on the *H. robusta* larvae at the rate of 3 per day and consumed thirty-six larvae during its life span of 12 days. This species is well distributed in Doon Valley.

Vertebrata : Aves

Passeriformes : *The common Myna* (*Acridotheres tristis*) (Linnaeus) (Sturnidae). Observations showed that these Mynas feast on larvae and pupae of *H. robusta* during peak fruit boring population in May-June. The bird is omnivorous. It is fond of insects. The common Myna is found practically all over India including Himalaya up to about 2000 m elevation.

Mammalia

Rodentia : *Funambulus pennanti* Wr. (Sciuridae). (The five striped squirrel) (Plate 1, fig. f.). Squirrels have been observed predating upon *H. robusta* larvae and pupae during May-June. Their food is the usual food of all squirrels fruits, nuts, young shoots and buds Larvae and pupae of insect are eaten at a pinch as also the

eggs of birds. The five striped squirrel *F. pennanti* is distinctive in having five pale stripes on its back, three medium, pale, dorsal stripes flanked on each side with supplementary pale stripes. It inhabits the Indian peninsula from the base of Himalaya southwards.

Conclusions

Predators recorded so far are found only in small numbers and do not appear to play an important role in the control of the pest accept the assassin bug *A. rama* and perhaps the sepoy ant *T. rufonigra*. But it may be worthwhile studying their behaviour in order to indroduce them into another country. All predators are potentially promising biological control ngents. There are many examples from literature where, species of predators mass reared and released have effectively controlled pests both in agriculture and forestry (Sweetman 1963). It is worthwhile to study the possibilities of releasing these predators of Old World in New World for control of an allied species of *H. robusta*, *H. grandella* another Meliaceae shoot borer of Neotropics where it is a serious pest of mahoganies and *Cedrela odorata*.

SUMMARY

The Meliaceae shoot borer *Hypsipyla robusta* Moore an important pest of trees belonging to family Meliaceae. A survey for the predators of *H. robusta* in Doon Valley revealed five predators including one reduvid, one formicid, two carabids, one mantid, common myna and five striped squirrel were recorded for the first time. A brief account of the predators and their potentialities are given in this paper.

निम्ब कुल के प्ररोह छिद्रक हिप्सीपायला रोबस्टा मूर (शल्किपक्षा : पाइरालिडी)
के हिंस्र कीटों के नये आलेख

प्रताप सिंह व राम मोहन मिश्र

सारांश

निम्ब कुल की वृक्ष जातियों पर लगने वाला निम्ब कुल प्ररोह छिद्रक कीट हिप्सीपायला रोबस्टा एक महत्वपूर्ण नाशकीट है। हि० रोबस्टा के हिंस्र कीटों का एक सर्वेक्षण दून घाटी में किया गया। इसके हिंस्रक प्रथम बार आलेखित किए गए जिनमें एक मत्कुण, एक चींटी, दो सींग वालेभृंग, एक बद्धहस्त पांच कीट सामान्य मैना और पांच प्रकार की धारियों वाली गिलहरियां भी हैं। हिंस्रकों का संक्षिप्त वर्णन और इस कीड़े का नियन्त्रण करने में उनकी संभावनाएं भी इस अभिपत्र मे बताई गई है।

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PERICONIA LEAF SPOTTING AND BLIGHT OF *HEVEA BRASILIENSIS* A NEW DISEASE FROM INDIA

M.D. MEHROTRA*

State Forest Service College-cum-Research Centre, Burnihat (Assam)

Introduction

Hevea brasiliensis (N.B.K.) Muell. Arg., considered native to South America, has become an important plantation crop in countries both in eastern and western hemispheres. It is now grown in a number of countries of Asia and equitorial Africa. In India, although Kerala is the chief rubber producing State, the rubber plant is also grown in Tamil Nadu, Karnataka and Andaman Islands. In recent years the feasibility of growing *Hevea* in the north-eastern States has been ascertained in view of the congenial environmental conditions such as uniformly high temperature and well distributed rain fall for most part of the year.

The Rubber Research Institute at Guwahati has established nurseries and also taken up rubber plantations in different north-eastern States e.g. at Sorutari at Burnihat, Assam in an area of about 15 hectares, at Canol and Darechikgre in Tura, Meghalaya in about 15 and 20 hectares respectively, at Agartala in Tripura in about 66 hectares and at Kalasib in Mizoram in about 50 hectares. Besides, rubber plantation has been started by private agencies as well with all the technical know—how being made available to them by the Rubber Research Institute, Guwahati. One such plantation has recently come into existence near Jorabat about 15 km from Guwahati under Don Bosco management where grafted seedlings have been planted. The Assam State Forest Department has also recently established a rubber nursery at Rani under Social Forestry about 35 km from Guwahati. There is a small but old rubber plantation at Soil Conservation Training Institute, Burnihat where tapping of rubber has been started recently.

A scanning of the literature shows that a number of pathogenic fungi causing severe and minor leaf diseases have been recorded on *H. brasiliensis* in India of which the important ones are *Phytopthora palmivora* Butler, *Oidium heveae* Steinmann, *Drechslera heveae* (Petch.) Ellis and *Corynespora cassiicola* (Berk. & Curt.) Wei.

Periconia manihoticola (Vincens) Viegas is known to cause severe leaf disease on rubber and Manihot in Brazil, Costa Rica and Mexico (Ellis, 1971). Though the fungus has been reported by Mehrotra *et al.* (1985) causing leaf spot in *Sterculia versicolor* Wall. from Burnihat, Assam, it has not been reported on *Hevea* yet. The disease is being reported for the first time from India and is described.

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* Presently at : Tropical Pine Research Centre, Forest Research Institute, Dehra Dun.

Disease incidence, symptoms and epidemiology

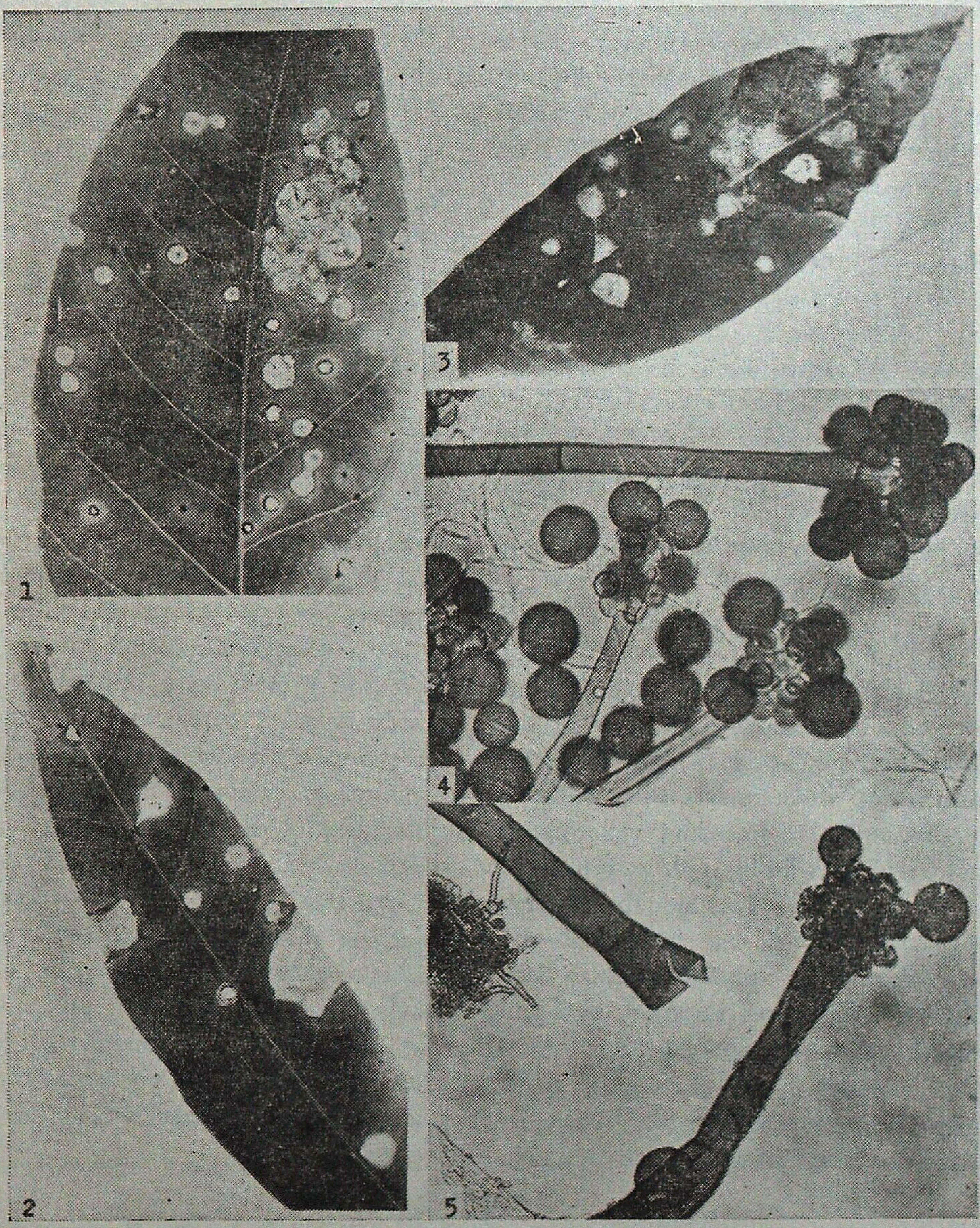
During the disease survey conducted in the social forestry nursery at Rani in January, 1988, the author noticed an interesting foliar disease in 4-months-old seedlings. It is for the first time the rubber seedlings were raised in the nursery in about one acre plot having about 150 beds. The nursery is located at the border of Assam and Meghalaya and there is a range of low lying hills on Meghalaya side with sal growing naturally. A portion of the nursery has rows of trees on its two sides which obviously provide shade to the nearby nursery beds. It was of interest to note that the disease was prevalent in the beds partially shaded in this portion of the nursery. On the other hand, the beds in the rest of the nursery were almost free from the disease. The incidence of the disease in the shaded beds was so high that almost all the seedlings in the beds were in the grip of the disease. The damage to the seedlings was to varying extent from a few spots to many spots and in severe cases a number of spots developed in a close proximity coalesced covering a much larger leaf area and thus presented a blighted appearance. Heavily infected leaves were eventually shed prematurely.

The infection spots developed, at first, as dark brown small dots of pin head size which later increased and were distinguishable into the central papery white portion with a charateristic dark brown border. The spots were usually sub-circular to oval, usually between 4 mm to 12 mm in size and were spread all over the lamina both on the margins and in the middle portion. Some of them were abnormally large and at times angular. The central portion eventually dried and turned brittle and was torn off and shed in pieces leaving shot hole. The heavily infected leaves curved inwards due to the contraction of the infected tissues on drying particularly when attacked on the margin or in the middle portion invading a larger area. The pathogen sporulated on the upper surface with sporulating structures produced abundantly in the central papery white portion as tiny black masses. Cool winter nights and dew and the dew remaining for a relatively much longer duration on the leaves in shaded beds were congenial for the development of the disease. Dew perhaps also helped in spread of the disease on the leaf after the fungus produced sporulating structures. The pathogen did not attack the leaves when they were purple green in colour. It is only when they had become green and were fully developed, they were attacked by the pathogen. The disease was almost absent in one year old grafted plants and also 2-3 years old plants growing in the same nursery in an adjoining plot. Occasionally, only a few leaves developed one or two spots. The disease situation was almost the same in a private one year old plantation at Burnihat. Thus it is very much evident that the young seedlings in the nursery are prone to attack by the pathogen if they grow in partially shaded beds. The disease although continued up to March-April it appeared to be on the decline. Further observations are needed and thy will be reported elsewhere (Plate 1, figs. 1-3).

Causal organism

The causal organism was isolated and

Plate 1



Figs. 1–5. *Periconia manihoticola* on *Hevea brasiliensis*. 1–3. Leaves showing spots and the extent of damage. 4. Conidiophores and conidia from the culture, x 300. 5. Conidiophores and conidia from the host, x 300.

cultured on potato dextrose agar medium. It was identified as *Periconia manihoticola* (Vincens) Viegas. The fungus grew slowly on PDA giving the colony a blackish appearance due to heavy sporulation. Later on the fungus produced white cottony growth and on aging the culture was covered with dirty white to light brown fungus hyphae showing patches of black sporulating structures; reverse greyish black; hyphae branched, septate, 2.5-10.0 μm in width; conidiophores on the host shorter, dark brown, usually with one septum and occasionally with two septa, broader at the base, 2225-330×28-45 μm whereas in culture conidiophores longer and brown, 310-630×17-27.5 μm; conidia spherical, brown, verrucose, 27.5-39.5 μm with no difference in size both in nature and in culture (Plate 1, figs. 4-5).

Pathogenicity test

The pathogenicity tests were conducted successfully on 6-month-old seedlings by inoculating the leaves with a small piece of inoculum from a 4-day-old culture on both the sides and covering the inoculum with a thin layer of cotton soaked in sterilized water. The inoculated leaves were covered with a ploythene bag containing water soaked cotton swab sufficient enough to maintain adequate humidity. The uninoculated leaves covered with a polythene bag having a humid atmosphere served as control. The leaves inoculated on the lower surface developed typical disease symptoms in 4-5 days. The spots were developed in close proximity at the site of inoculum. None of the leaves inoculated on the upper surface developed the disease.

Laboratory bioassay of fungicides

The study *in vitro* showed that the fungus failed to grow altogether in the presence of Dithane M-45 (0.2%) and Bavistin (0.1%) but showed only negligible growth stretching from the inoculum in the presence of Blitox (0.2%).

Control

Since the disease appeared in shaded beds and was almost absent in beds fully exposed to the sun, it is advisable to establish the nurseries in open area to preclude attack of the young seedlings by the pathogen. A constant surveillance of nurseries is, however, necessary to monitor the disease situation as it has been found to occur in virulent form although in shaded beds only. There is no room for complacency as the pathogen may develop enough inoculum potential in course of time as it sporulates abundantly on rubber and also on *S. versicolor* a widely distributed forest tree species and thus may pose a serious threat to the rubber nurseries in time to come. In view of this a nursery experiment has been set up to test the efficacy of different fungicides against the disease in the shaded portion of the nursery at Rani and the results will be reported elsewhere.

Acknowledgements

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SUMMARY

Leaf spotting and blight of *Hevea brasiliensis* (N.B.K.) Muell. Arg. caused by *Periconia manihoticola* (Vincens) Viegas is a new disease reported for the first time from India. The pathogen attacks the young seedlings and causes significant damage to the foliage and premature defoliation. Cool nights and dew favour the development of the disease in shaded beds. The absence of the disease in beds fully exposed to the sun indicates that it can be checked or averted by establishing the nurseries in open areas. A laboratory bioassay of fungicides showed that Bavistin and Dithane M–45 are quite effective as the fungus failed to grow altogether in the presence of these fungicides.

हीविया ब्रैजिलिएन्सिस की पत्तियों पर पेरिकोनिया से द ग पड़ना तथा अंगमारी
भारत से मिला एक नया रोग

एम० डी० मेहरोत्रा

सारांश

हीविया ब्रैजिलिएन्सिस म्यूल० आर्ग० की पत्तियों पर पेरिकोनिया मैनिहोटिकोला (विंसंस) वीगास से दाग पडना और अंगमारी भारत से प्रथम बार सूचित किया गया इसका नया रोग है। यह रोगजन छोटे पौधों पर लगता है और उसकी पत्तियों को काफी हानि पहुँचता है। समयपूर्व निष्पत्रण भी कर डालता है। ठंडी रात और ओस छायादार क्यारियों में इस रोग के अनुकूल और विकास प्रेरक है। धूप आने वाली क्यारियों में इस रोग के न होने से संकेत मिलता है कि इसकी रोकथाम खुले स्थानों मे क्यारियां बनाकर की जा सकती है। प्रयोगशाला में कवकनाशियों के जीवों पर किये गए परीक्षण से पता चला कि बाविस्टिन और डायथेन एम० 45 कवक के प्रति प्रभावकारी हैं क्योंकि इन कवकनाशियों के प्रयोग से यह कवक पनप ही नहीं सका।

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INCIDENCE OF BABOOL BORER *CELOSTERNA SCABRATOR* FABRICIUS (LAMINAE : CERAMBYCIDAE; COLEOPTERA) ON *EUCALYPTUS* IN MALNAD TRACTS OF SHIMOGA

B. SHIVAYOGESHWARA, H. MALLIKARJUNAIAH, N.K. KRISHNA PRASAD AND K.G.S. DAS

University of Agricultural Sciences, Hebbal, Bangalore (Karnataka)

Introduction

Celosterna scabrator F. is popularly known as Babool borer, a highly polyphagous species attacking many forest trees like *Acacia*, *Casuarina* and *Prosopis* (Beeson, 1931, 1941) and plants like cotton and rose (Fletcher, 1914). This pest was first observed on *Eucalyptus* during 1968 at Changulpet, Tamilnadu (Chatterjee and Singh 1968).

Reports of incidence were received from plantations of Mysore Paper Mills located at Sowlanga and Salbal area of Shimoga district. A reconnaisance survey of the affected areas was therefore made to assess the extent of damage and to observe the feeding behaviour (Table 1). The details of the observations are presented in this paper.

Observations

The survey was conducted between the months of September and November 1986 in the affected areas. Beetles were found damaging young plants, one to two year old, of *Eucalyptus*. The percentage of damage of plants was 45 in Sowlanga area and 36 in Salbal plantations.

The feeding was observed from morning till evening. One to four beetles were found on the plants. Generally, both the sexes were noticed feeding on the same plant. Beetles feed on the bark and partially on the Xylem tissues resulting in girdling of the main stem and/or the branches (Fig. 1). Damage intensity was much more than their

Fig. 1

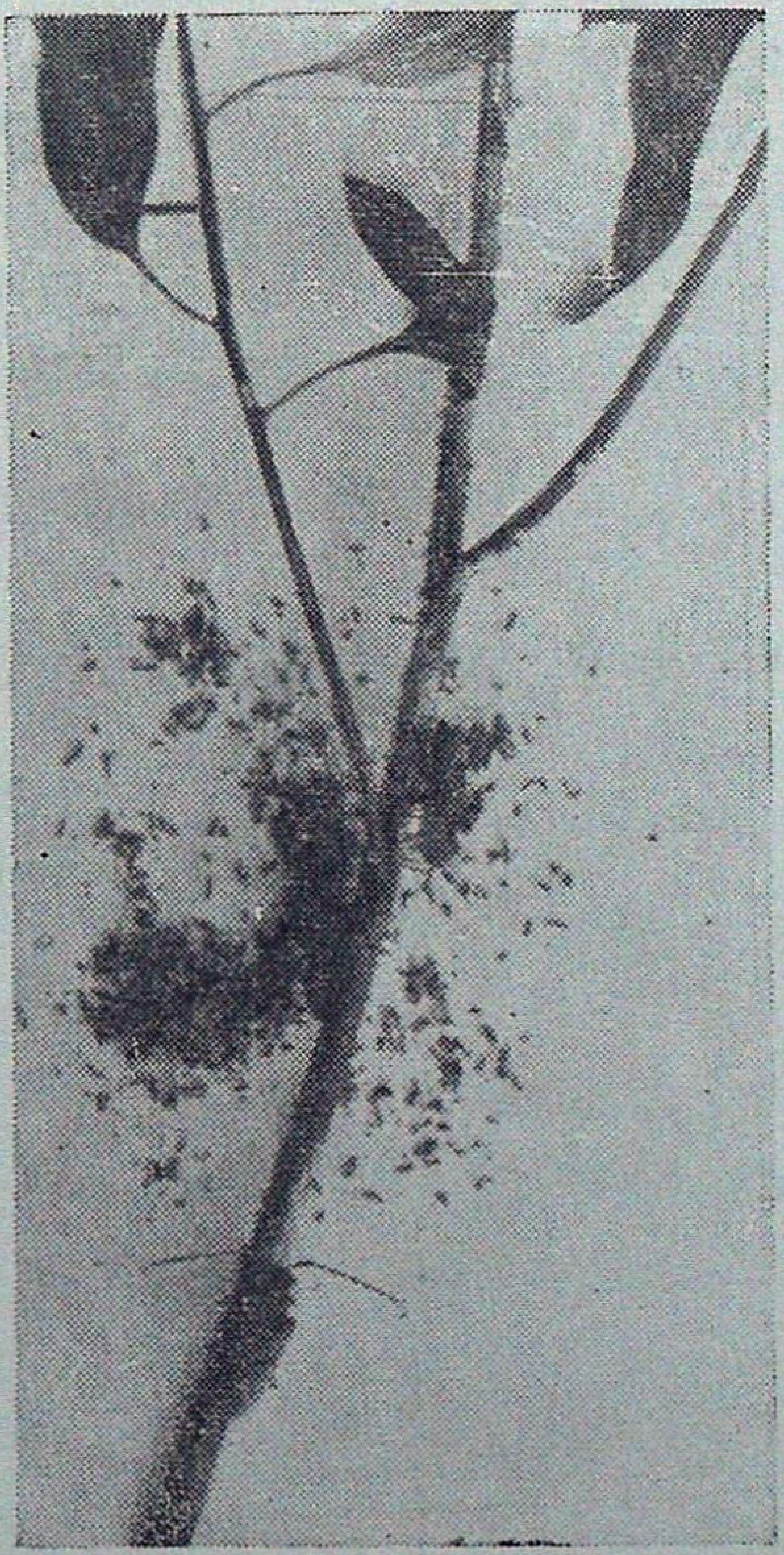

Table 1

Damage intensity due to Celosterna scabrator F.

Plant No.	Plant height (cm)	Unfed length of main stem (cm)	Feed length of main stem (cm)	No. of branches fed	Feed length of branch/es (cm)	Unfed length of upper half portion (cm)	Per cent of damage of main stem
1	154	93	31	1	3	30	20.12
2	135	80.5	4.5	0	—	50	3.33
3	100	67	13	0	—	20	13.00
4	105	34	28	0	—	43	26.66
5	95	34	38	2 (a, b)	a.20, b.10	23	40.00
6	110	45	40	1	3	25	36.36
7	120	55	5	3 (a, b, c)	a.9, b.8, c.6	60	4.16
8	130	80	25	2 (a, b)	a.,5 b.9	25	19.23
9	110	45	15	1	3	50	13.63
10	136	70	30	0	—	36	22.05
11	130	66	14	1	10	50	10.76
12	110	58	7	0	—	45	6.36
13	125	85	20	0	—	20	16.00
14	110	70	12	1	10	28	10.90
15	140	80	25	2 (a, b)	a.7, b.10	35	17.85
16	130	53	50	1	12	27	38.46
17	90	35	30	0	—	25	33.33
18	130	44	60	3 (a, b, c)	a.25, b.30 c.20	26	46.15
19	90	45	15	0	—	30	16.66
20	100	40	40	0	—	20	40.00
21	95	30	35	0	—	30	36 84
22	90	45	22	0	—	23	24.44
23	130	110	0	1	15	20	0.00
24	100	45	25	0	—	30	25.00
25	130	65	15	0	—	50	11.53
26	280	235	10	0	—	35	3.57
27	126	66	22	0	—	38	7.46
28	140	75	25	2 (a, b)	a.5, b.20	40	11.85
29	140	50	60	2 (a, b)	a.20, b.5	30	42.85
30	150	38	80	1	6	32	53.33
Mean	124 36	64.68	26.55	—	9.03	33.20	22.26

actual feeding requirement. Chewed fibre heaps could be seen on the ground indicating the existence of the beetles and the damage intensity. The maximum percentage of feed length out of 30 plants was 53 33 and average being 22.26. Girdled region of the main stem ranged from 4.5 cm to 80.00 cm. Where as on the branches it ranged from 3 cm to 40 cm. Average feed length of main stem and branches was 27 cm and 9 cm respectively. Girdling was uniform and continuous in most of the plants and it was partial in a few cases. However, interestingly the point of contact of the leaves to the twig was found to be not attacked. Plants girdled 20 cm and more could not withstand the shock of the damage and the accumulated growth above the girdle. The result was a break in the plant and/or a branch in most cases due to wind followed by withering and drying. The damage to the plant will be more pronounced after a few weeks of feeding due to irregular thickening of the plant. Beetles were selective in feeding on the branches. Water sprouts, succulent branches and thick hardy basal portion of the plant were not preferred. Average height of the plant was 124 cm, of which basal 64 cm and top 33 cm was not affected indicating that lower part of the upper half portion was the most preferred feeding site.

In the same area, the beetles were also found feeding on two other bushy plants but not on cotton a host plant found nearby. However, the damage was not critical on *Eucalyptus* plants aged over three years. Further, assumed that the recent outbreak of this pest on *Eucalyptus* is possibly due to jungle clearance in those areas followed by monoculture of *Eucalyptus*. Intensity of damage was not appreciable in the vicinity where natural forest exists.

Preliminary laboratory screening of insecticides against this pest indicated that endosulfan at 0.07 per cent was promising.

Further an allround intensive investigations are in progress.

Acknowledgement

The authors wish to express their sincere thanks to staff of the Forest Department, Mysore Paper Mills, Bhadravathi for their kind co-operation. Also grateful to Dr. M.A. Singlachar, Associate Director of Research and Dr. K. Krishna Murthy, Director of Research for kind encouragement.

SUMMARY

Reconnaisance survey made on recent out break of Babool borer in *Eucalyptus* plantation indicated 22.26 per cent damage and the preferred zone of feeding was lower portion of the upper half of the main stem.

शिमोगा के मलनाड क्षेत्र के युकेलिप्टमों पर बबूल छिद्रक सीलोस्टर्ना स्कैब्रेटर फैब्रिसिय
(लैमिनी : दीर्घशृगक वंश : कंचुकपक्षा) का आपात

बी० शिवयोगेश्वर, एच० मल्लिकार्जुनैया, एन०के० कृष्णप्रसाद व के०जी०एस० दास

सारांश

युकेलिप्टस रोपवन में कुछ समय हुए वृक्षों पर बड़े परिमाण में बबूल छिद्रक कीट लग जाने के पश्चात् सर्वेक्षण से पता चला कि इससे 22.26% हानि पहुँची तथा कीड़ों ने अपना पोषण मुख्य तने के ऊपरी भाग के निचले अंश से प्राप्त किया।

References

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LETTER TO THE EDITOR

To

The Hony. Editor,
Indian Forester,
P.O. New Forest, Dehra Dun (U.P.)

Sir,

I have gone through the article 'Effectiveness of Aerial Seeding in Reclamation of Chambal Ravines in Madhya Pradesh' by Shri Ram Prasad in the Janury '88 issue of the *Indian Forester*. I would like to make the following observations :—

Given the locality factors, both edaphic and climatic, in Chambal ravines it is highly improbable that sowing done after surface cultivation of the soil will even succeed, let alone aerial seeding. Even if the seed dropped on the ground does get lodged on the ravine slopes and manages to germinate during the rainy season when moisture is available, the young seedling with its roots having penetrated only a few centimetres of the soil will hardly be able to withstand the drought conditions that prevail after the rains when the column of the soil upto which the roots have penetrated will be baked dry by the autumn sun. In our State I have seen that sowings carried out of chil on bare slopes in the month of June gave excellent germination during the rainy season and thereafter all the seedlings died as a result of the intense autumn sun which completely baked the column of soil into which the roots of young seedlings had managed to penetrate This has happened to patch sowings done with due care in areas where rainfall is much more than 800 mm per annum and moisture stress is not as acute as can be experienced in Chambal ravines or the tropical wastelands of our country. It was only when we resorted to planting of chil raised in polythene bags that we were able to raise excellent plantations on bare grasslands/grazing lands available for afforestation. Similarly broad-leaved fodder plants planted as naked root plants on exposed, warm aspects gave very good results while sowings with these species were largely a failure. With planting done and the plant roots being about 30 cm to 45 cm (30 cm in case of chil and 45 cm in case of broad-leaved) below the surface upto which sunshine cannot penetrate sufficient moisture could be retained in the root zone to tide over the dry autumn. Therefore, I feel that for successful afforestation of ravine lands, wastelands and desert lands planting alone has a chance to succeed in this country. There can be in my opinion no shortcut and only way to bring about ecological rehabilitation of these degraded lands is to go in for planting with suitable species which demands increased allocation of funds and also perhaps at the same time greater accountability on the part of professional forester.

Thanking you,

Yours faithfully,
Sd./- (P.L. Kaul)
Project-Manager
Indo-German Dhauladhar Project, Palampur
Distt. Kangra (Himachal Pradesh)

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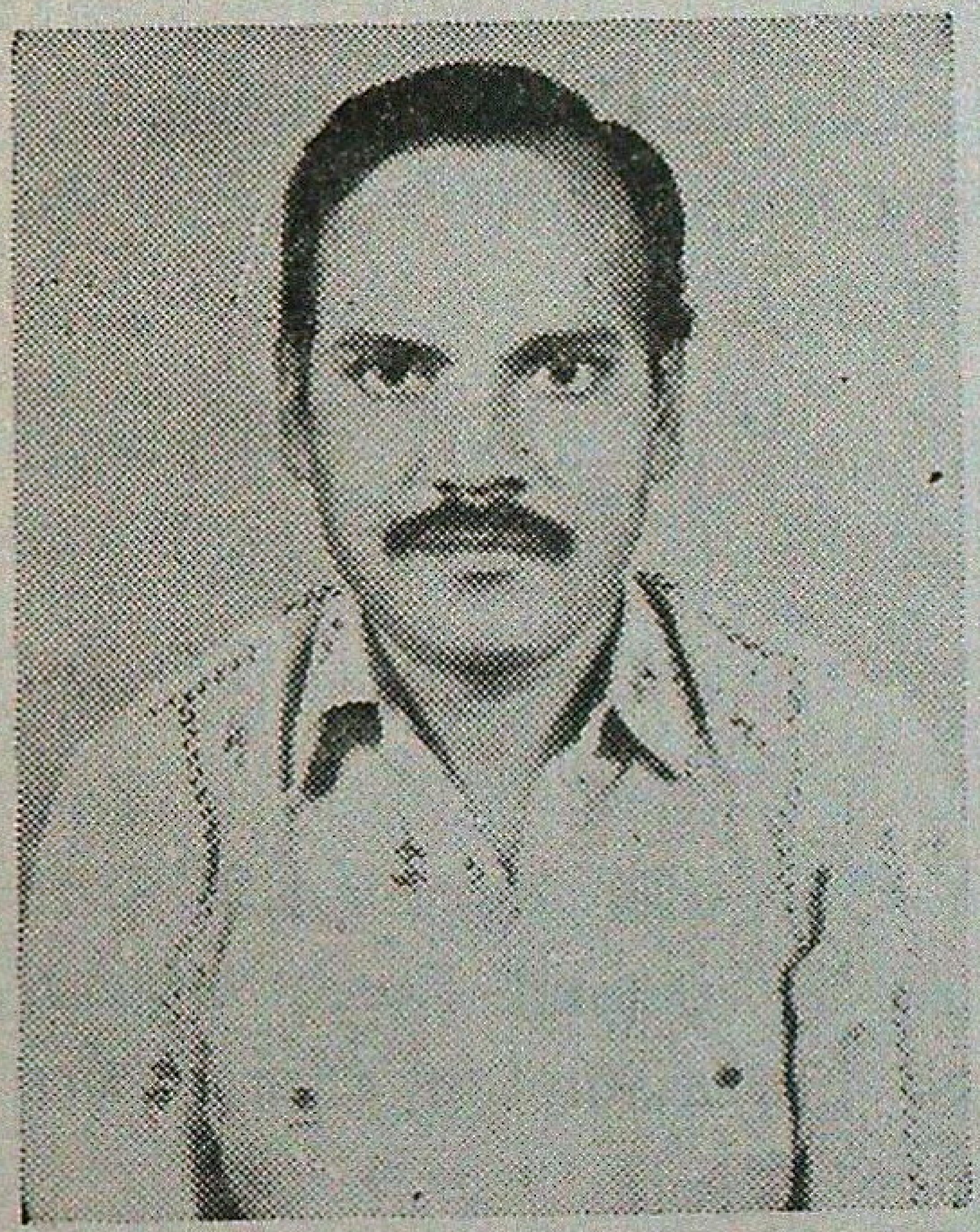

Shri Shyam Dhar, I.F.S., Deputy Conservator of Forests, of Kerala Cadre, on deputation as Senior Research Officer, Forest Economics Branch, Forest Research Institute, Dehra Dun died in an accident (a tree fell on his car) on 4-6-88 at New Forest.

After doing the M.Sc. from Allahabad University in 1974, he joined the Indian Forest College and passed out in 1977-79 course. He was alloted to the Kerala Cadre. He served there in various forest divisions. He was deputed to the Forest Research Institute, Dehra Dun in 1987.

He is survived by his wife, three daughters, colleagues, admirers and whole society of the foresters to mourn his untimely demise.

May God give peace to the departed soul.

G.P.M.

GAZETTE NOTIFICATIONS

ANDHRA PRADESH GAZETTE

The services of Shri A.H. Mooswi, I.F.S., Conservator of Forests, are withdrawn from Andhra Pradesh Forest Development Corporation Ltd., and on repatriation he is posted as Conservator of Forests, Warangal Circle *vice* Shri R.D. Reddy, I.F.S.

On transfer, Shri R.D. Reddy, Conservator of Forests is posted as Conservator of Forests (Research & Development Circle), Hyderabad *vice* Shri C.N. Rao, I.F.S.

On transfer, Shri C.N. Rao, I.F.S., Conservator of Forests is posted as Conservator of Forests, Soil Conservation Circle, Visakhapatnam.

Shri K.P. Muniswamy, I.F.S., Conservator of Forests, Anantapur Circle is transferred and posted as Conservator of Forests, Telugu Ganga Project Cuddapah relieving Shri K. Kesava Reddy, I.F.S., Additional Chief Conservator of Forests (D.P.A.P.).

Shri V. Janakiram Naidu, I.F.S., Conservator of Forests, on deputation to Tirumala Tirupathi Devasthanams, is re-called and posted as Conservator of Forests, Anantapur Circle, *vice* Shri K.P. Muniswamy, I.F.S.

WEST BENGAL GAZETTE

The Governor is pleased to appoint, until further orders, Shri S.K. Bardhan, WBFS, Divisional Forest Officer, Minor Forest Produce Division as Divisional Forest Officer, Durgapur Social Forestry Division with effect from the date of his assuming charge *vice* Shri J.N. Bhattacharyya, WBFS to superannuate.

The Governor is pleased to appoint, until further orders, Shri R. Deb Roy, WBFS, on reversion from his present deputation under the W.B.F.D.C. Ltd. as Divisional Forest Officer, Minor Forest Produce Division w.e.f. the date of his assuming charge *vice* Shri S.K. Bardhan, WBFS, transferred.

The Governor is pleased to appoint, until further orders, Shri S.R. Mukherjee, WBFS, Additional Divisional Forest Officer, Cooch Behar Division as Divisional Forest Officer, Raiganj Social Forestry Division with effect from the date of his assuming charge.

The Governor is pleased to place the services of Shri B.B. Mullick, WBJFS, Assistant Divisional Forest Officer, West Midnapore Division at the disposal of the W.B.F.D.C. Ltd. for appointment as Assistant Divisional Manager under the said Corporation, until further orders.

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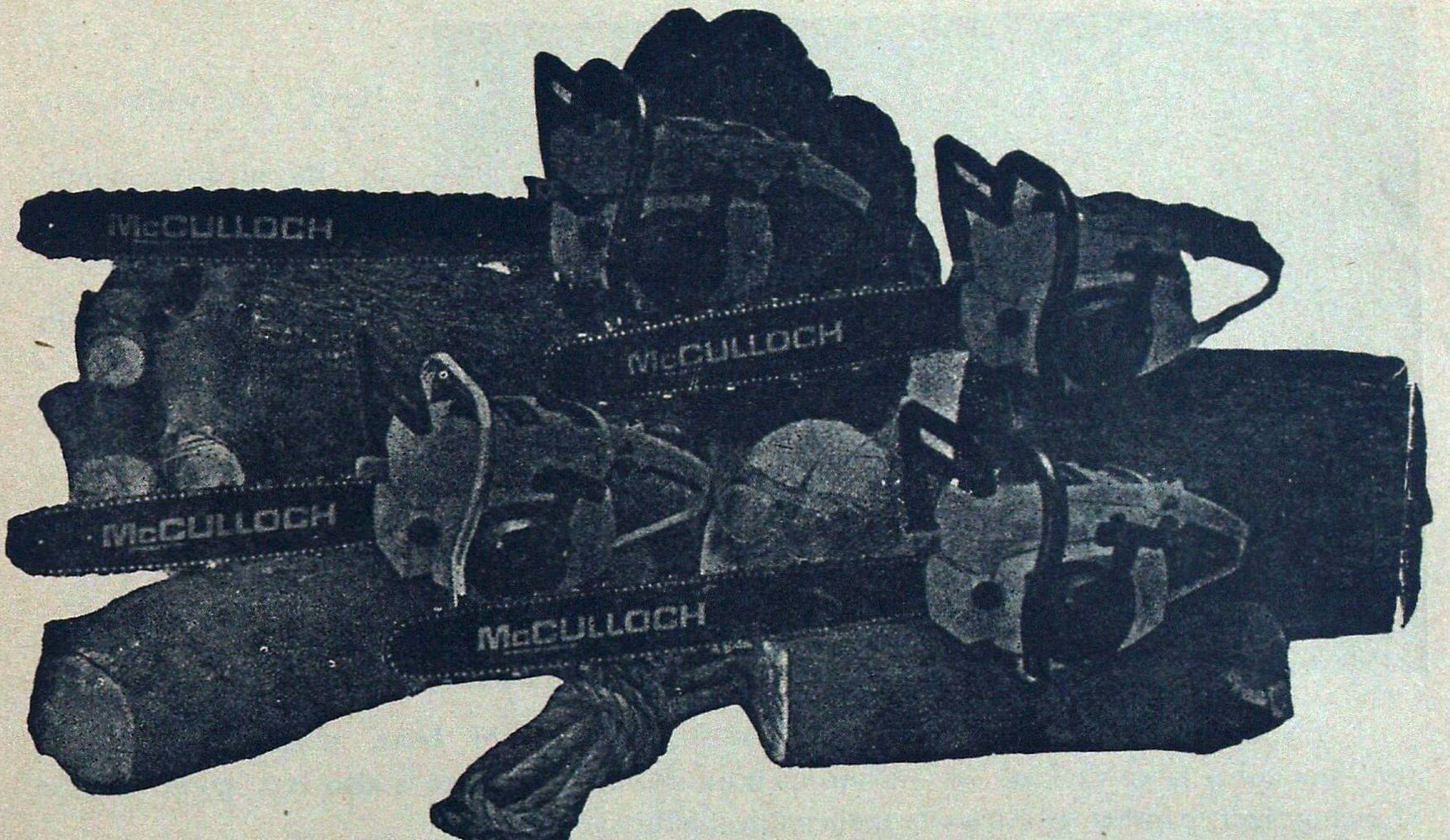

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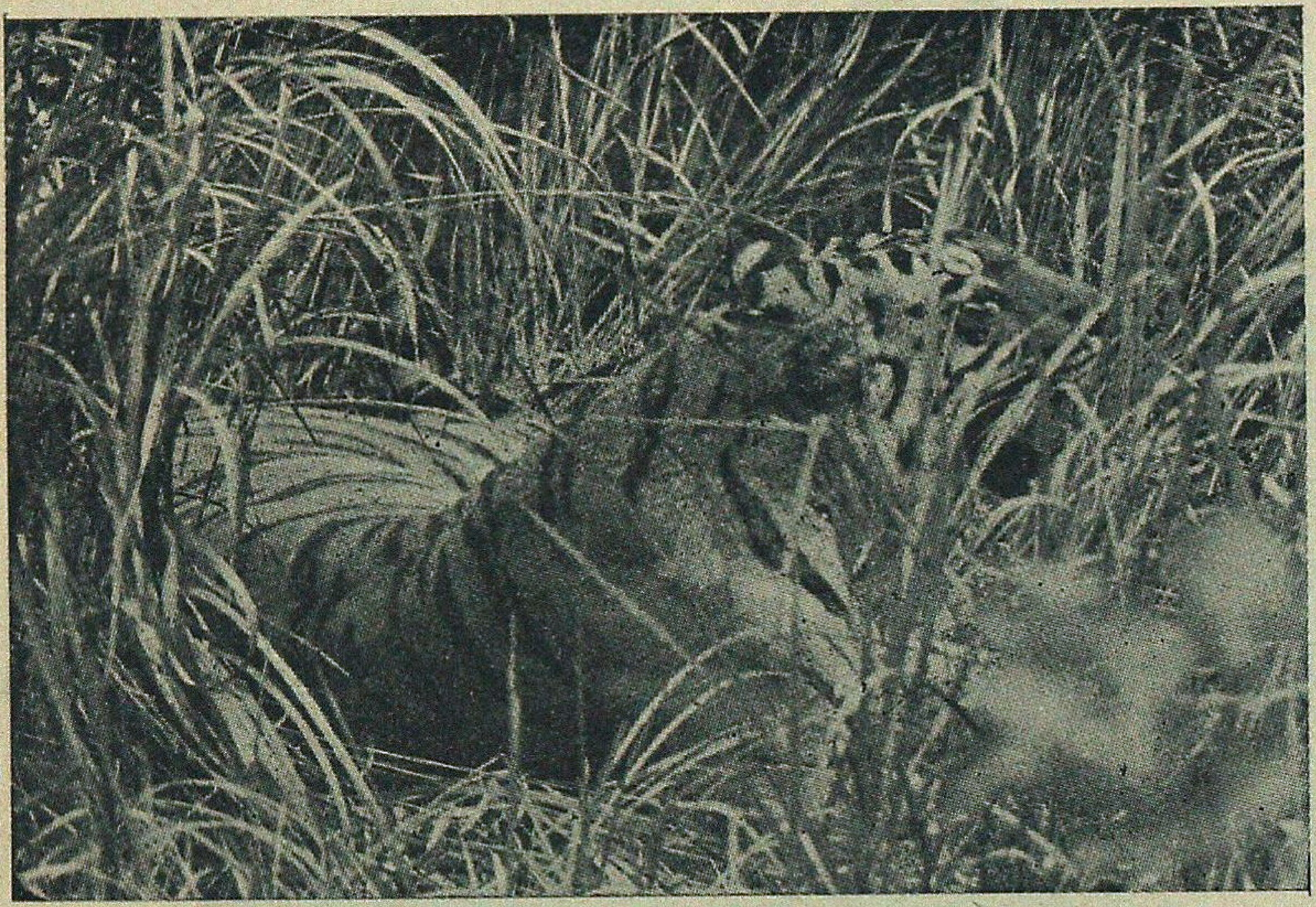

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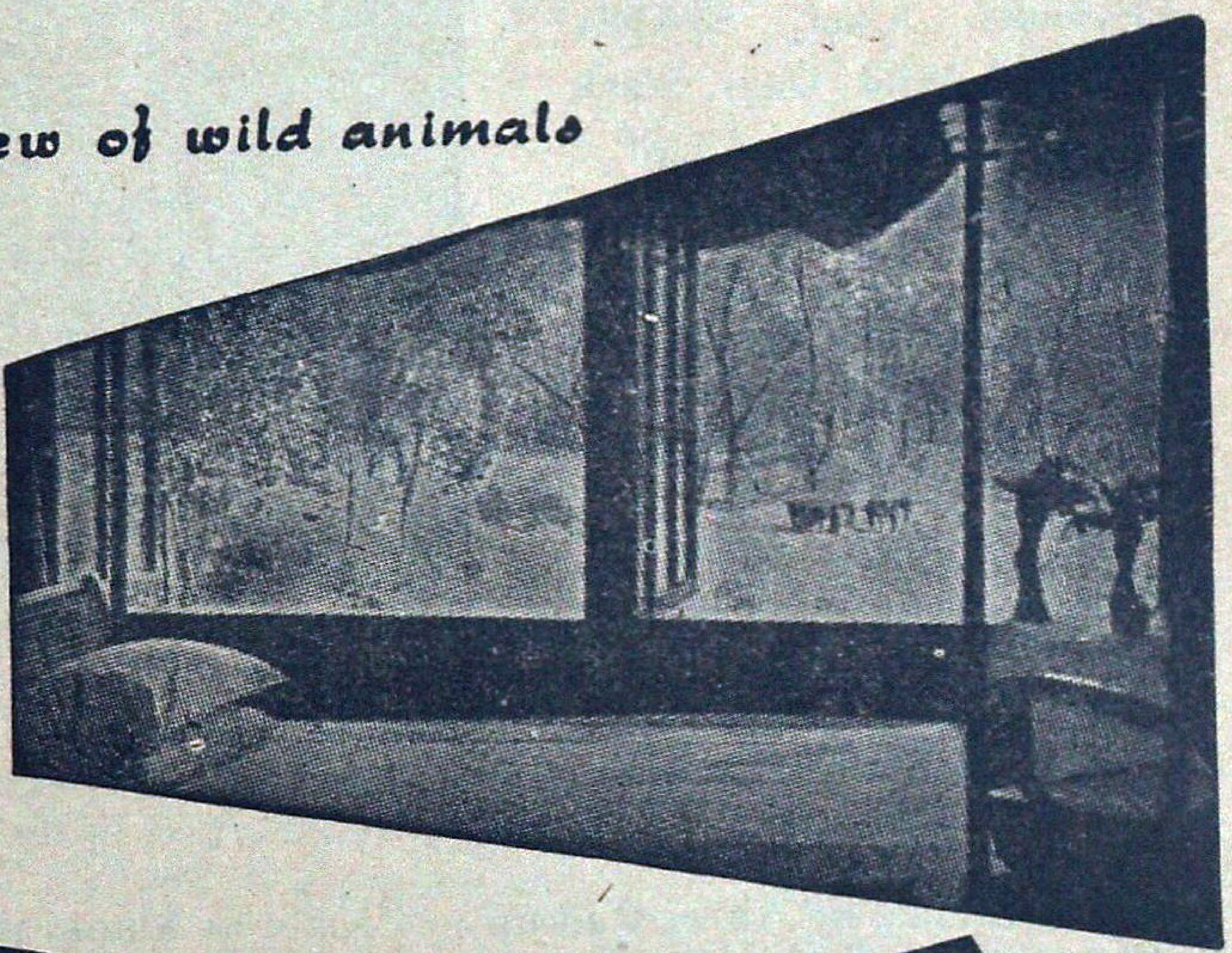

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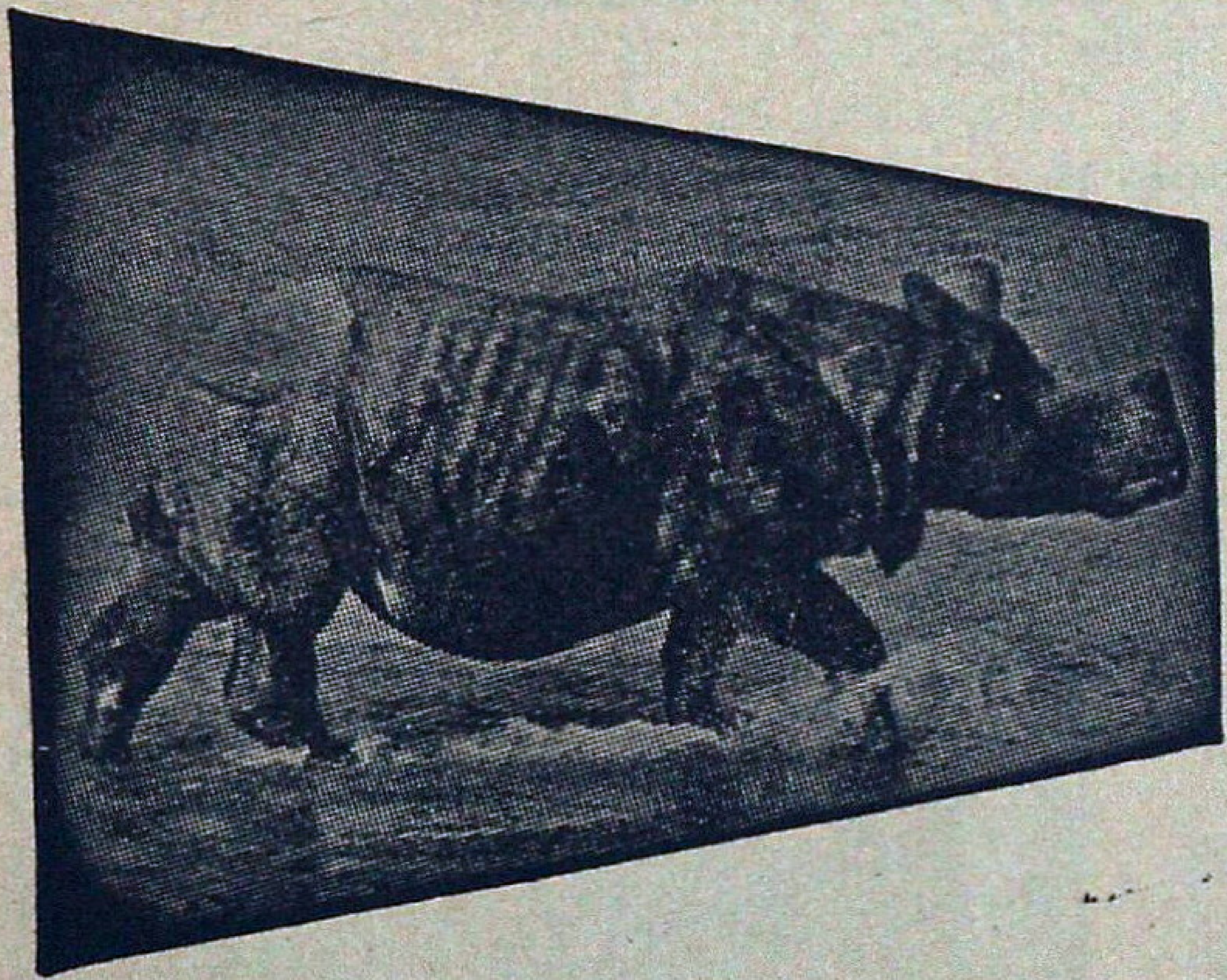

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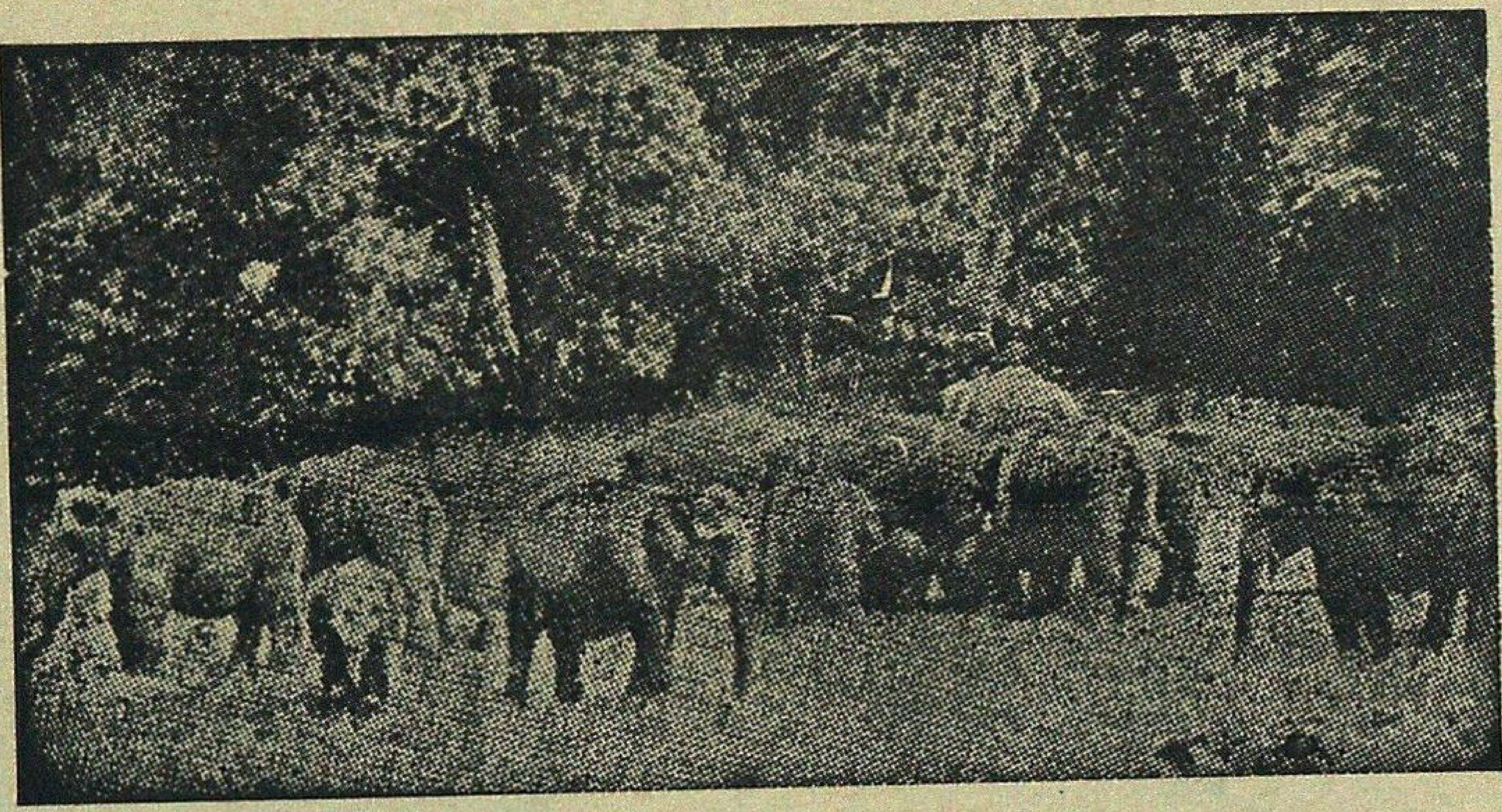

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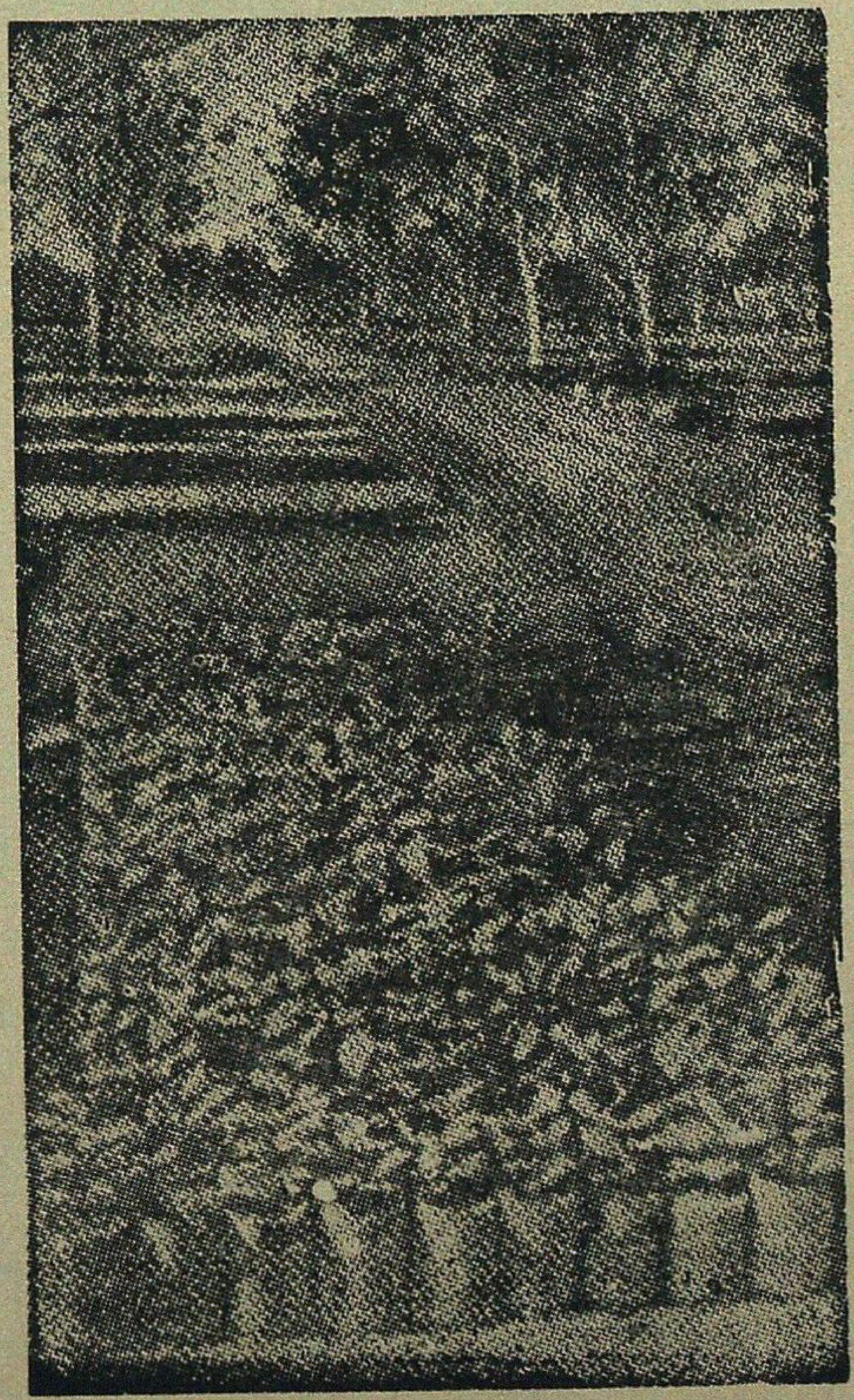

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Himachal Pradesh State Forest Corporation Ltd.

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SHIMLA

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c) Providing incentives to officers and staff through prompt action on service matters like confirmations, job rotation vis-to-vis career planning including specialized training.

(V.P. Mohan)
Managing Director.

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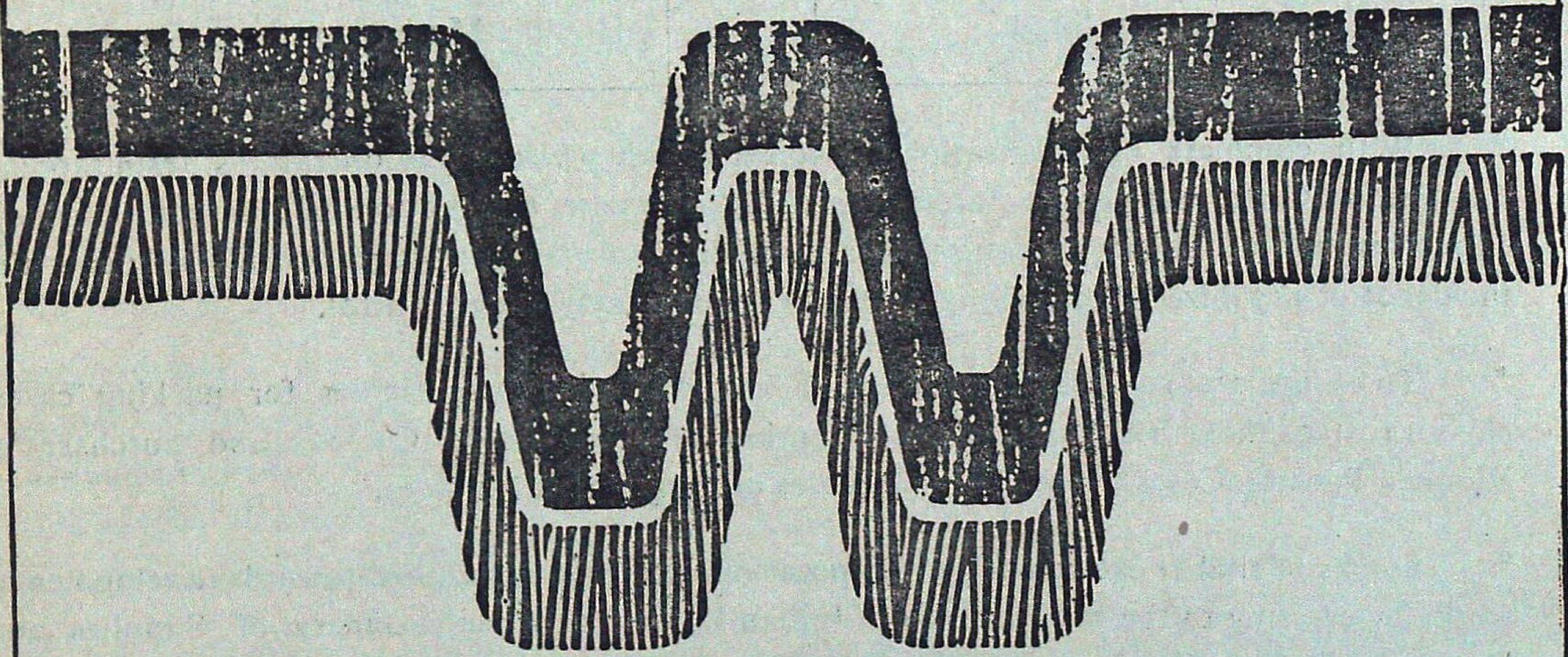

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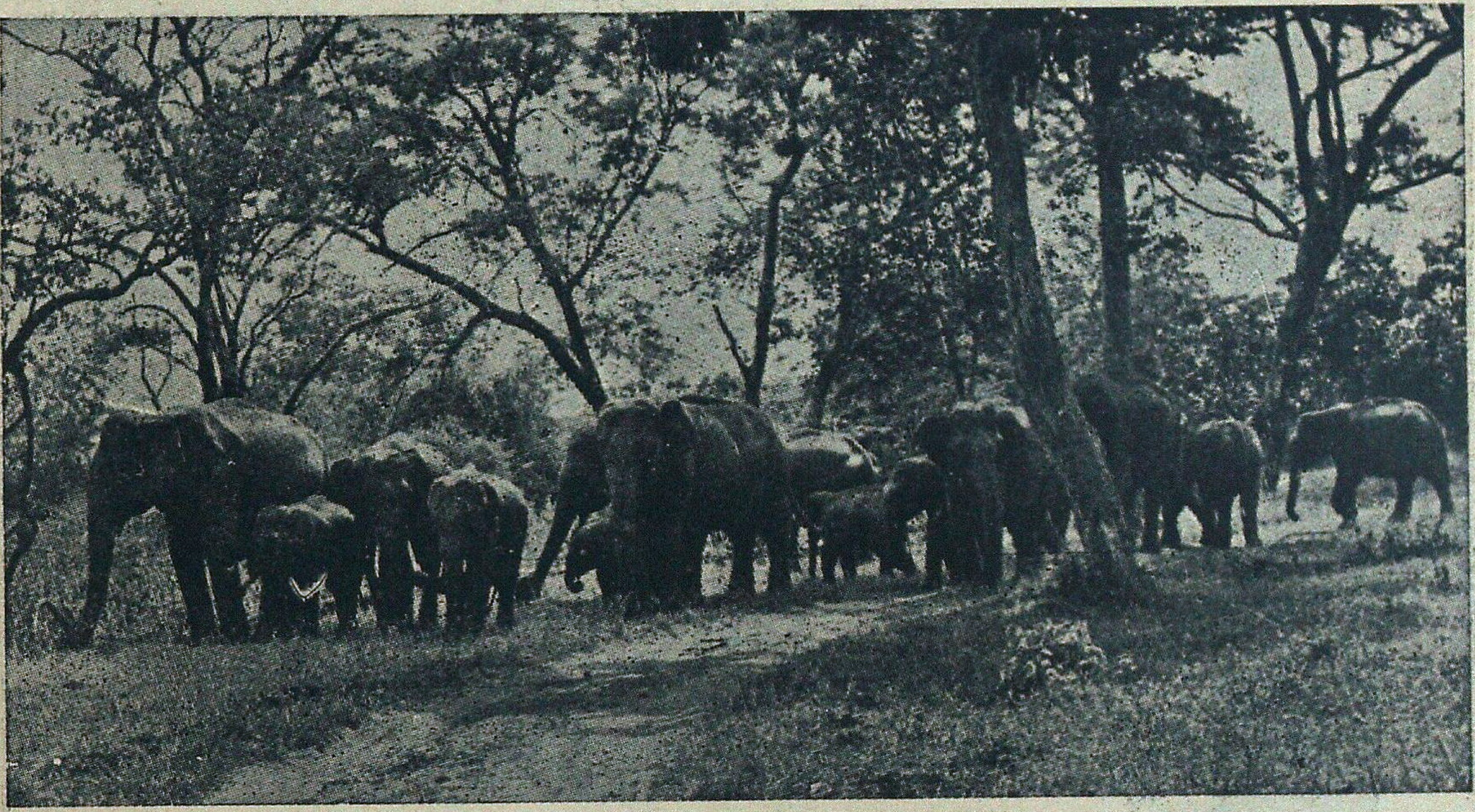
BANDIPUR TIGER RESERVE

KARNATAKA



Lovers of nature and Wildlife the world over find it well worth their while to linger on in Bandipur. More famous as a Tiger Reserve, Bandipur enjoys reputation as a wildlife sanctuary that stretches as far back as 1931. The Mysore Maharajas; benign rulers and farsighted visionaries understood the compelling necessity of protecting the fauna, avifauna and flora from the thoughtless foreys of marauders. Today 874 sq kms. of the Bandipur National Park makes up the Tiger Reserve which is one of India's finest parks.

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Government House Complex
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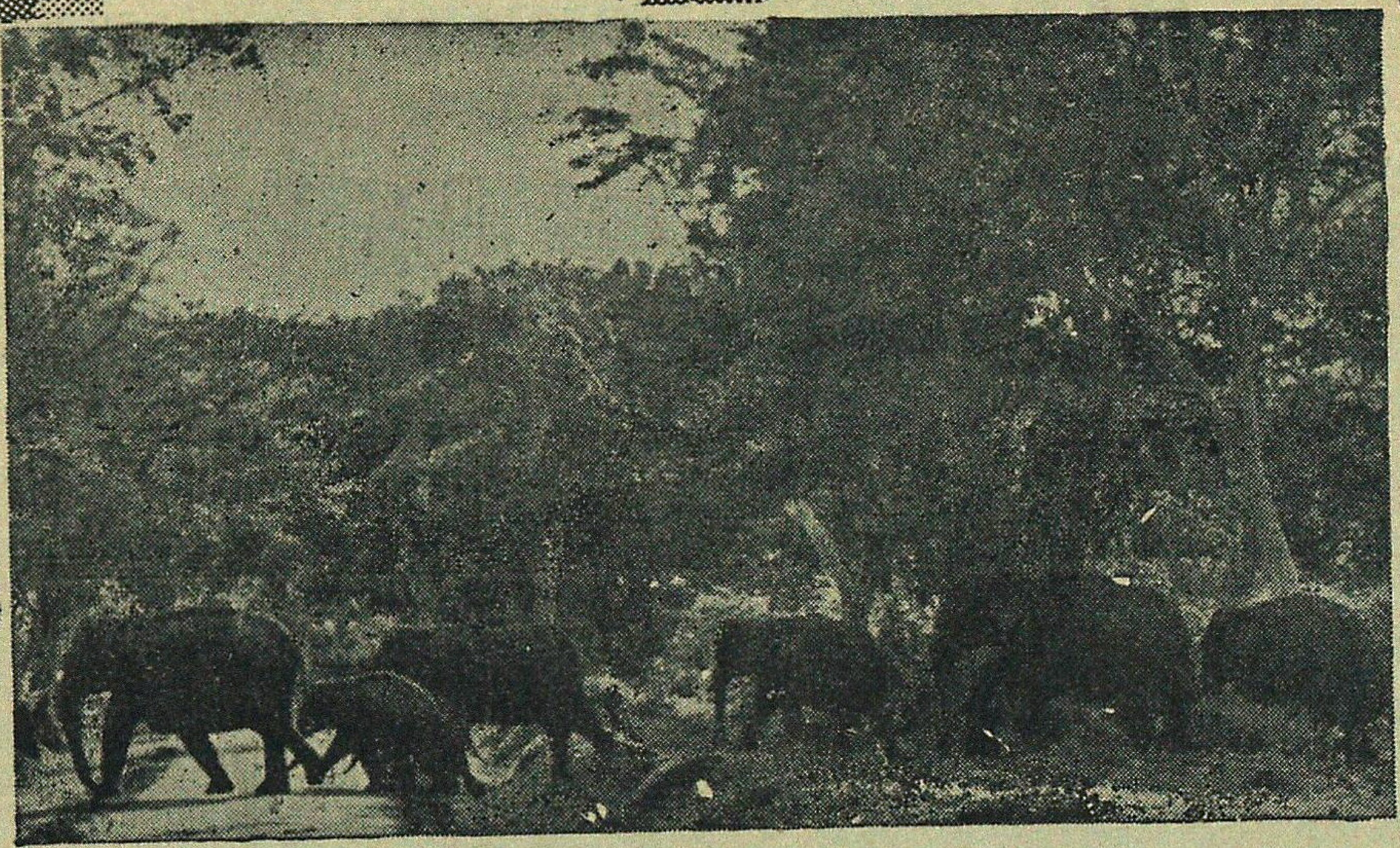
(Karnataka—State)—India
Telephone No. 20901



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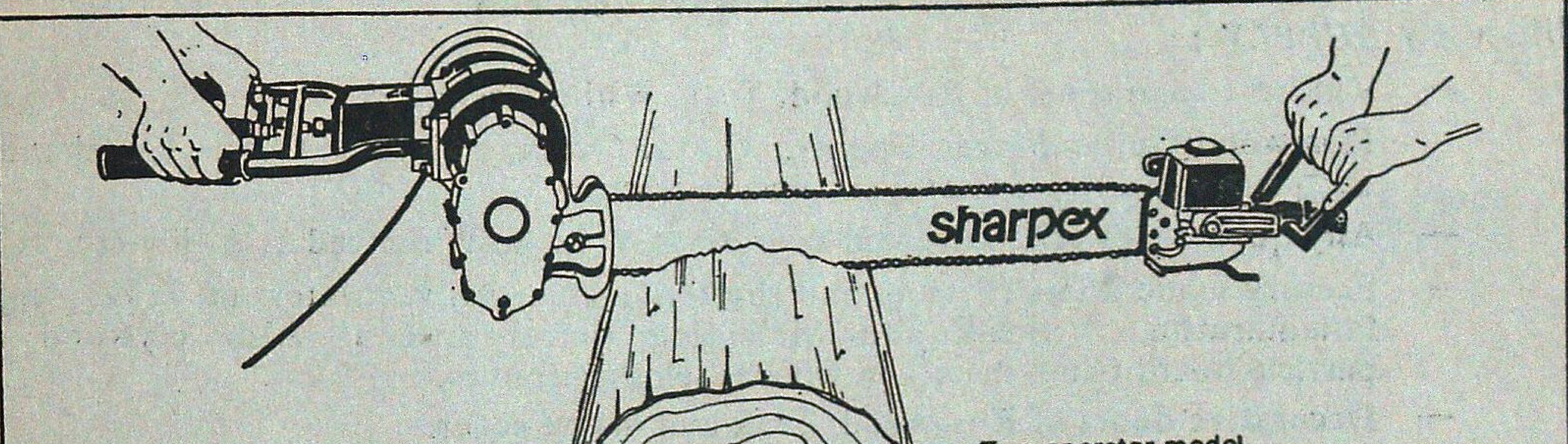
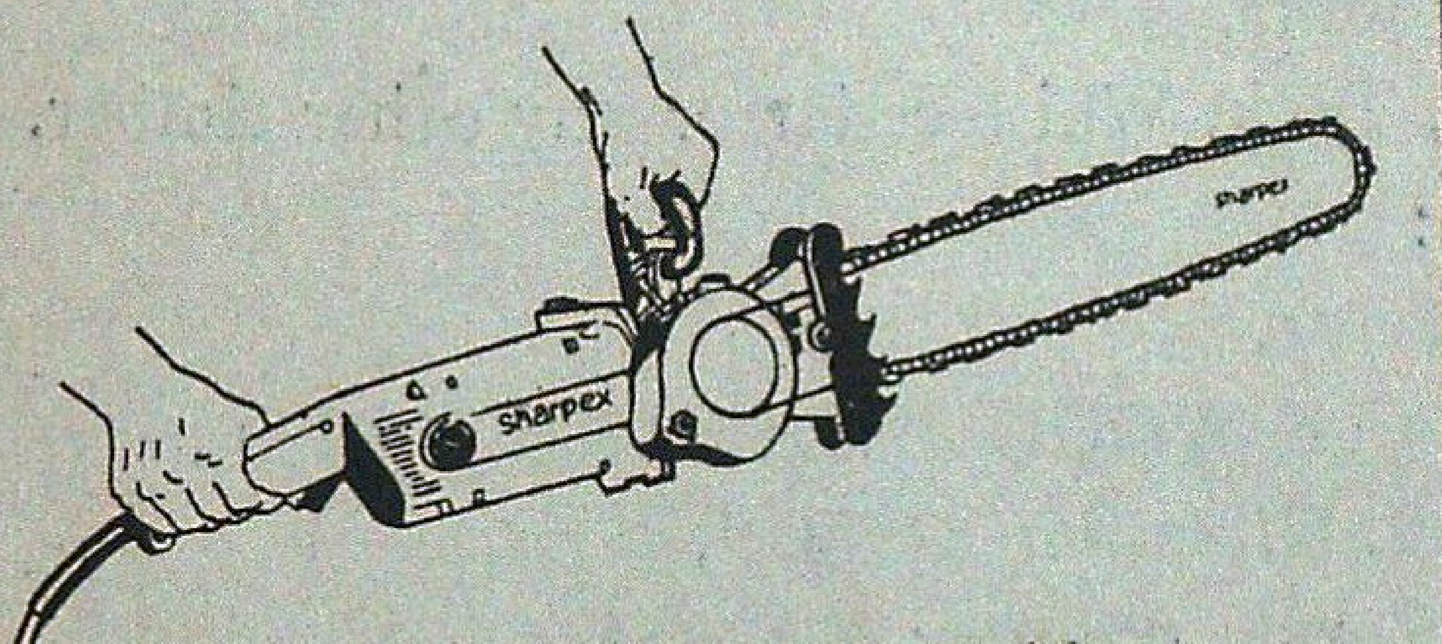


Two operator model



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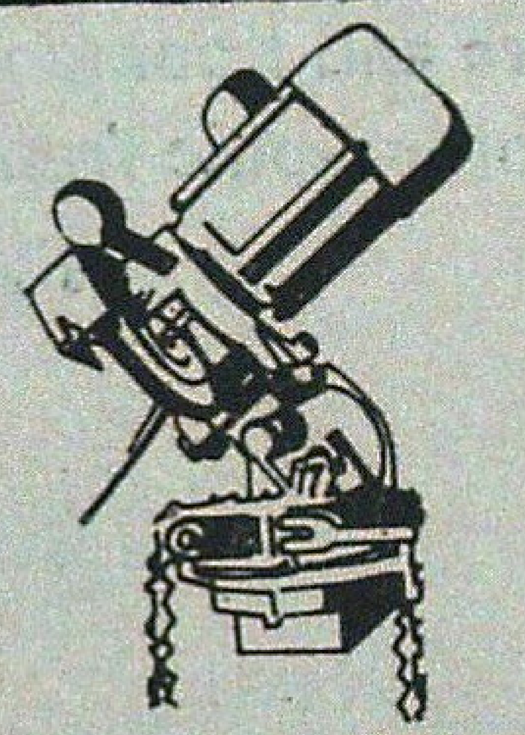

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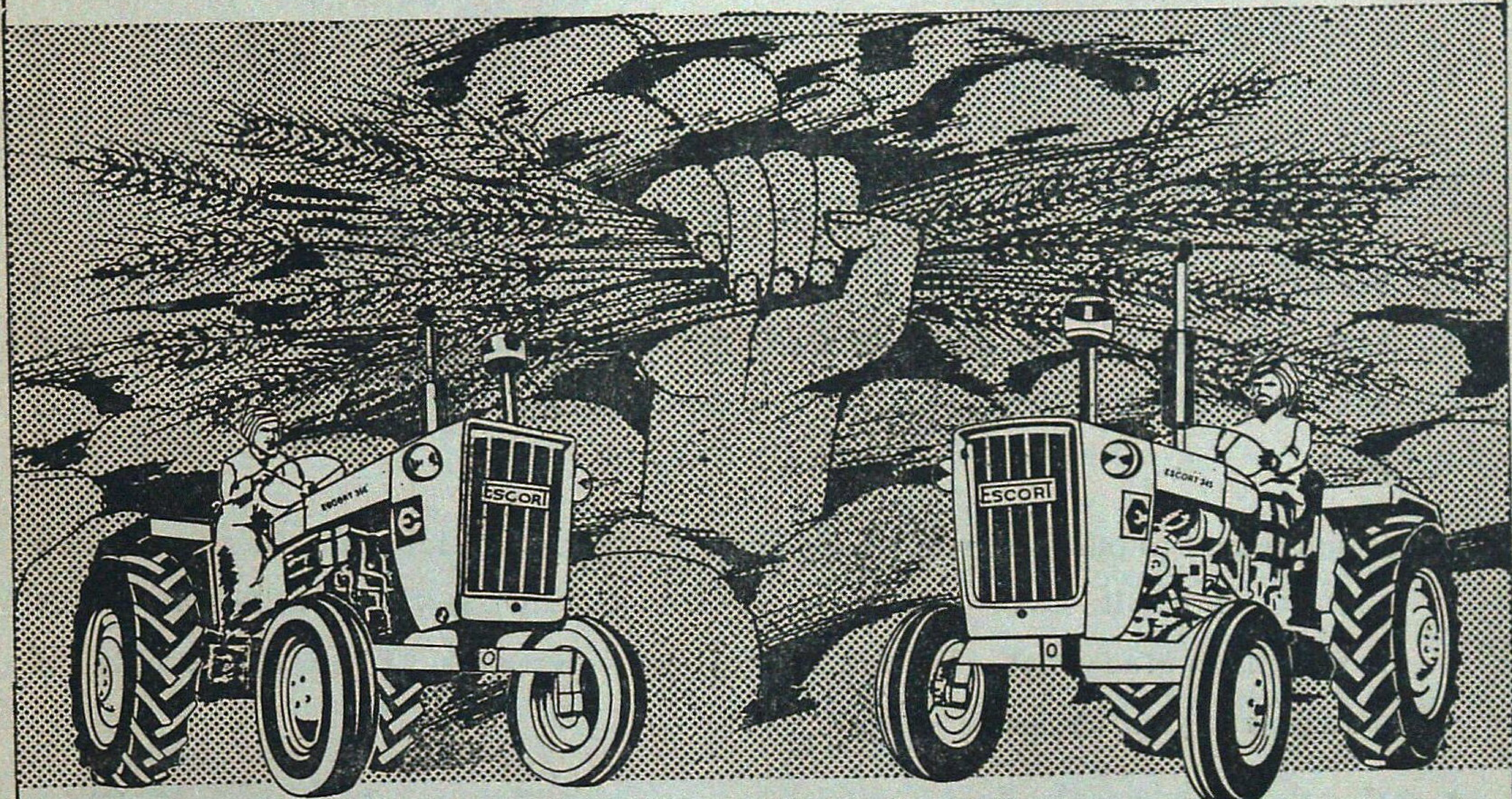

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Mizoram Forests Through The Years

During the British period i.e. from 1890 till the year 1952, the management of Inner Line Reserved Forests was done under the supervision of Superintendent of District. The District was put under 'Excluded Area' and practically no Statutory Act or Law were enforced to manage the Forests. Practically nothing had been done. The Inner Line Reserved Forests was constituted under the Assam Forest Regulation comprising an area of 559 sq. kms.

When the Mizo District Council came into being in 1952, the management of all the Forest other than the State Inner Line Reserved Forests was handled by the District Council. Thence the District Council started to make its own Forest Wing. Under the District Council one Forest Division called Aizawl Forest Division was created comprising the then whole area with headquarters at Aizawl. In fact during the time of the then District Council, most accessible areas of the forests had been overtapped for earning more revenue and due to population pressures.

In the early 1960's the first plantations were raised by the District Council in different centres. During the year 1966–1968, practically no plantation could be raised due to political disturbance in the Mizo District.

After Mizoram became a Union Territory in the year 1972, the Union Territory Government formed one more Forest Division with headquarters at Lunglei.

The present position of Mizoram Forest Department may be summed up as follows :

The Mizoram Forest Department is headed by the Chief Conservator of Forests. The field work has been taken up with ten (10) Territorial Divisions. In addition to this, six (6) Functional Divisions have been set up. There are now three (3) Circles namely—Southern Circle, Northern Circle and Research & Development Circle. The Government of Mizoram has already eonstituted three Wildlife Sanctuaries in order to preserve its vanishing Wildlife. Four more Wildlife Sanctuaries are being proposed which are likely to be constituted very soon. The Mizoram Forest Department has created 1,00,029 hectares of plantation upto 1987 as against 967 hactares before it attained U.T. Status.

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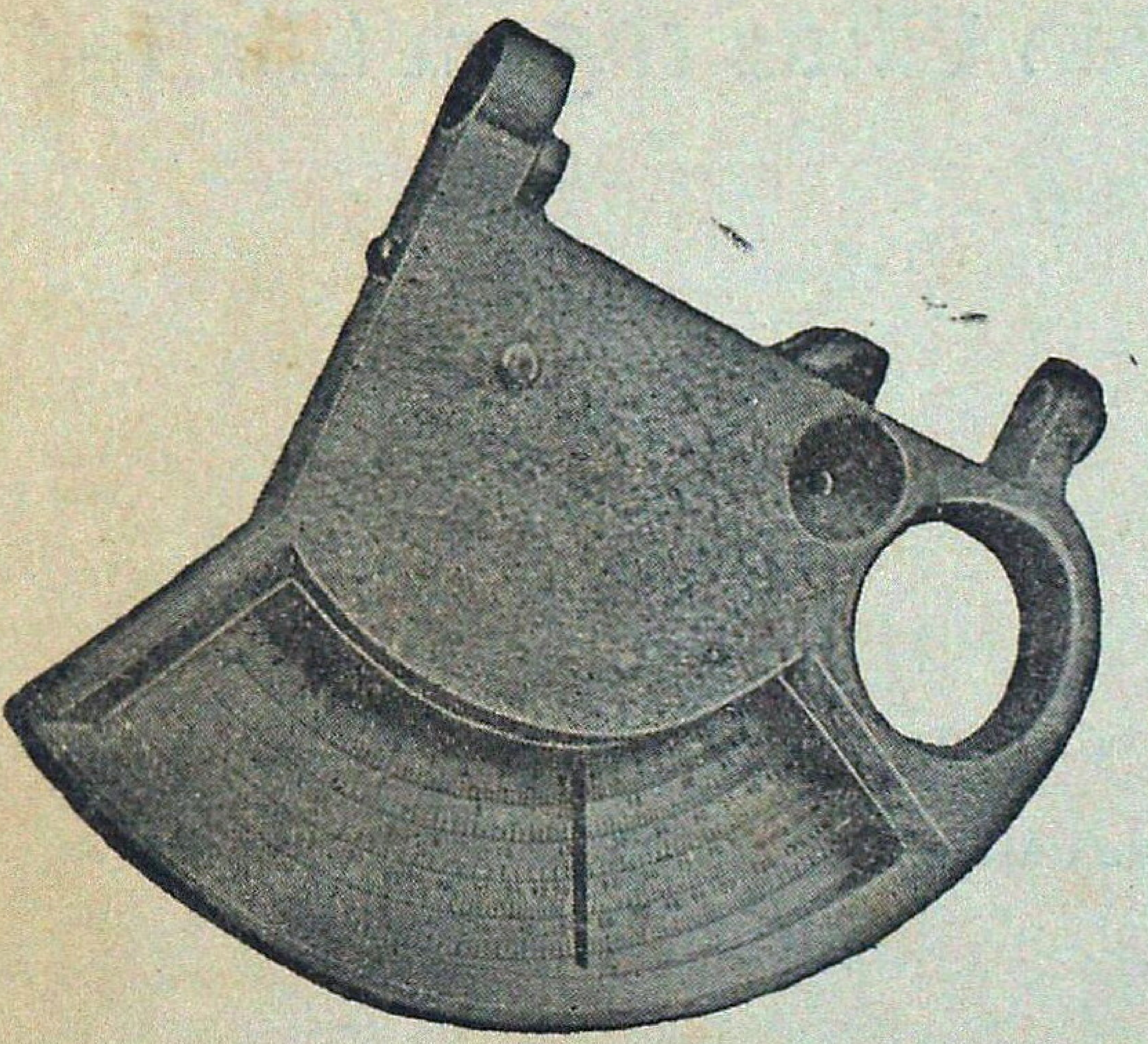

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THE
INDIAN FORESTER

VOLUME 114 JULY, 1988 NUMBER 7

SEED STAND OF *PINUS ROXBURGHII*, RAMPUR (HIMACHAL PRADESH).
Photo—D.P. Uniyal ... Front Cover

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